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John.Cloud@noaa.gov

Sailing Close to the Wind: Superintendent Thorn Rescues the Coast and Geodetic Survey (1885-1889)

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Frank Manly Thorn (1836-1907)

Frank Manly Thorn was Superintendent of the US Coast and Geodetic Survey from 1885 to 1889. He was the first non-scientist to lead the Survey, and also the Survey's first leader since Benjamin Peirce who didn't leave by death, or by disgrace, in

the case of his predecessor, Julius Hilgard. His ascendancy was so closely linked to Hilgard's fall that some summary of events in the years before Thorn's arrival is necessary.

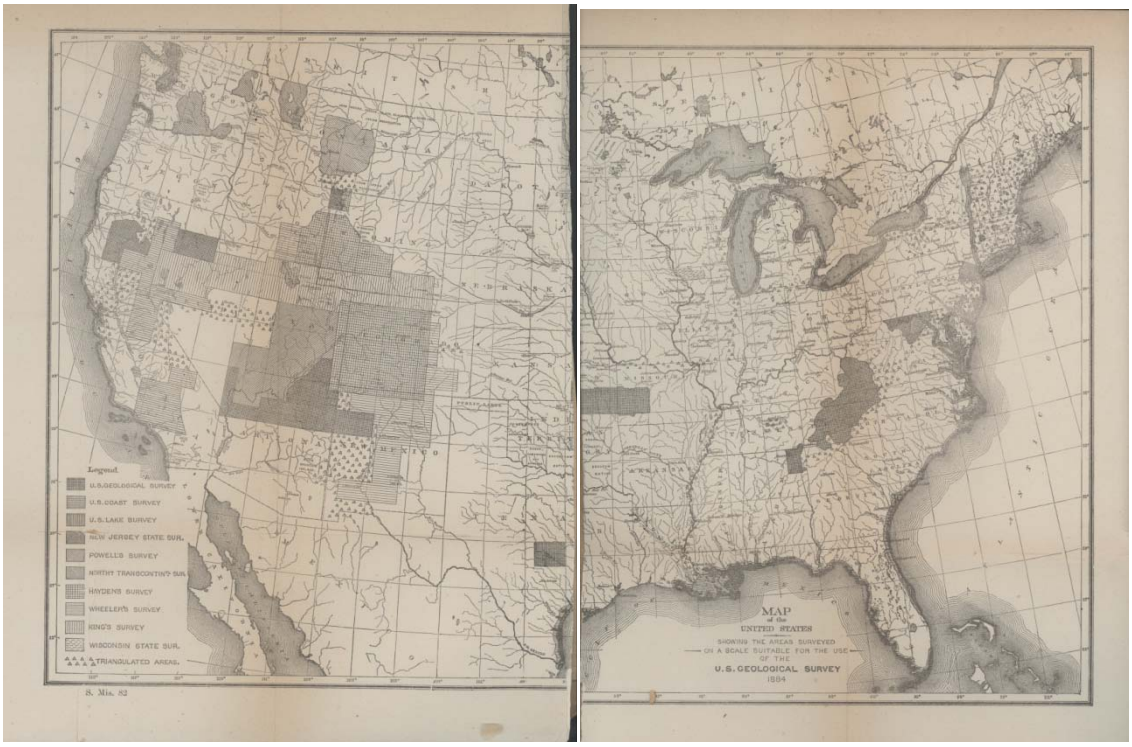
The Allison Commission, Chenowith, the Coast Survey, and American Science

During the tenure of Benjamin Peirce (1867-1874) the budget of the Coast Survey almost doubled from what it had been at the end of A.D. Bache's tenure. The tenures of Carlile Patterson (1874-1881) and Julius Hilgard (1881-1885) were very different. The Panic of 1873 issued in a a period of financial instability and political uncertainty, compounded by labor struggles and strikes and bank failures which eventually engulfed the operations of all agencies in the American government. Patronage and the spoils systems, and efforts to combat them, caused increased scrutiny of federal agencies and their operations and efficiencies.

For the federal scientific agencies, these culminated in the investigations of the Allison Commission (1884-1887), which was a special commission jointly organized by the US Senate and House of Representatives, to investigate the workings and inter-relationships of the US Coast and Geodetic Survey, the US Geological Survey, the Signal Service of the US Army (the predecessor of the Weather Bureau), and the Naval Hydrographic Office. The scale and scope of the hearings and investigations of the Commission were unprecedented in American history, and the voluminous documentation the investigation yielded have made the Allison Commission a signal and much-studied event in the history of American science.[1]

Given the scholarly attention already directed at the Commission, we need only summarize the major issues that impacted the fate of the Coast and Geodetic Survey. Essentially, there were three Venn diagram arenas, two of which enclosed the Coast Survey. The first arena of contention was the Coast and Geodetic Survey and the US Geological Survey and the questions of the place of geodesy in a national science system, the relationship between geodetic networks and topographical mapping, the relationship between coastal oriented mapping and geodesy and the vast interior areas of the US portions of North America, etc. The second arena was inhabited by the US Coast and Geodetic Survey and the Naval Hydrographic Office; and the critical issue was whether or not the Coast Survey should be once again brought into the US Navy or not. Secondary, but also critical issues about the place and significance of geodetic networks in coastal charting and marine hydrography, were related to similar issues in the first arena. The third arena was occupied by the US Army Signal Service and the beginnings of the Weather Bureau. The issues at hand were whether or not such an agency should reside in the military or should become a civilian agency. This arena had little direct relation to the Coast and Geodetic Survey as such, except for the common issue of whether a scientific agency was best run by the military or under civilian control. As a result, the Coast and Geodetic Survey was under scrutiny in all three arenas of the Allison Commission.

[1] See especially Dupree, 1985, Rabbitt, 1980, Manning 1975 and 1988, Kevles 1995.



Areas of the US Suitable for topographic mapping by USGS
map prepared by USGS, 1884 and submitted to the Allison Commission
shaded areas had sufficient geodetic control for mapping

In the middle of the Commission's labors, which occupied portions of two sessions of Congress, in 1884 Grover Cleveland became the first Democrat elected President since 1856. When the Cleveland administration took office in March, 1885, every federal agency and bureau changed, from the top down. As was detailed in the Hilgard chapter, a Texas Democrat and former Confederate officer named James Q. Chenowith became First Auditor of the Department of the Treasury. He proceeded to investigate the workings of the Coast and Geodetic Survey, and then the Geological Survey, and finally the US Fish Commission. Chenowith had little impact in the latter two investigations, as they were by then prepared for his assault, but he had devastating impact on the Coast and Geodetic Survey.

Chenowith's issues revolved closely around money and whether or not agencies spent it correctly, with secondary issues about whether or not certain suites of scientific work were appropriate or not. In the case of the Survey, there were issues of expenditures on equipment and what had happened to the equipment, issues of people being paid whether they worked or not, older people being kept on formally basically as an informal method of providing pensions, which otherwise didn't exist, and so on. And there was a singular set of issues for the Survey concerning a system of per diem money for field expenses that had evolved over time since the Bache administration before the Civil War. Essentially, a system devised to provide extra money for both the extra expenses of field work, and also the lack of banks or other methods to secure money and

make purchases while in remote areas, had become a system in which workers throughout the agency received field per diem money whether or not they were out in the field. This had become accepted as augmented income, partially compensating the Survey workers for their notoriously low wages. Where the Survey saw better and fairer compensation, Chenowith saw embezzlement.

The Allison Commission investigations intersected Chenowith's own, and the result was the greatest crisis in the history of the Coast Survey. Superintendent Julius Hilgard was exposed and denounced as a drunkard, although it is still unclear exactly what his mental and physical state was at the time, with many participants in the Survey later on characterizing Hilgard's problems as being caused by some physical disease. But in any case, Hilgard was exposed and disgraced, and quickly forced to resign as Superintendent. In addition, four leading staff members at Survey headquarters were relieved of their posts, leaving the Survey in a perilous state. The immediate leadership was gone, remaining important personnel were paralyzed and frightened, the general corps of the Survey were in disarray, and the Allison Commission hearings had trumpeted positions that questioned and undermined the scientific legitimacy and appropriateness of the foundational work of the Survey.

Whatever else was to happen, it was clear there would not be and could not be another champion to rise from within the ranks of the Survey to take over, right matters, and move the Survey forward. The entire agency had been tainted and compromised, and leadership could only come from without.

In March, 1885, the Cleveland administration began. In late June, a long-time political ally of Cleveland, also a citizen of Erie County, NY, came to Washington as a Cleveland appointee. On July 1, 1885, he began work as a special investigating agent of the Internal Revenue Service, assigned to the on-going investigations of the Survey. He served in that capacity from July1 to July 22, 1885. On July 23, he became the Acting Superintendent of the Coast and Geodetic Survey.

Frank Manly Thorn (Enters, Stage Right)

Frank Manly Thorn was born in Erie County near Buffalo in upstate New York, on December 7, 1836. His father was a lawyer, who became an elected official in various positions in Erie County. His son followed a similar path, at least at the beginning. Frank Thorn attended local schools, and then the Fredonia Academy in Fredonia, NY. He returned to Erie County and served as a clerk in Surrogate's Court, where his father was Surrogate Judge. Afterwards, young Thorn attended law school in Albany, the state capital. He was licensed as a lawyer—and then began to take a very different path in life. He relocated to Pennsylvania in 1860 where he worked in the early petroleum industry. After the Civil War, in 1867, he returned to Erie County, where he once again took up the legal profession—but he also established a productive fruit orchard and farm, and he began to write and publish humorous sketches in local newspapers using pseudonyms such as Hy Slocum, Carl Byng, and Frank Clive. He also performed as a humorist lecturer and after-dinner speaker, apparently with some success. He had less success

with his early writings as a result of issues of plagiarism. Samuel Clemens, or Mark Twain, purchased an interest in the *Buffalo Express*, one of the papers Thorn published material in. When evidence emerged that some piece written by Thorn in the *Buffalo Express* had been published elsewhere earlier, Twain himself was accused of the plagiarism. Upon investigation, Twain banned any further contributions from Hy Slocum and Carl Byng, writing characteristically to Thomas B. Aldrich, his original accuser of plagiarism, that he was doing it "for their **own good**—for everything they write is straightway saddled onto *me*".[2] By 1875, Thorn was re-publishing a piece previously published under a pseudonym under his own name in *Scribner's Monthly*.

In 1870, Thorn began his own political career. He was elected to the Erie County Board of Supervisors from 1870 to 1880. He joined the campaign of Grover Cleveland, his fellow local attorney, for Governor of New York in 1882, which was successful. Two years later, Cleveland was the Democratic candidate for US President, with Thorn campaigning actively on his behalf. Cleveland won in November, 1884, and was sworn in as President in March, 1885. He summoned Thorn from Erie County a few months later. And so it was that the man who became the sixth Superintendent of the Coast and Geodetic Survey had prepared for the position by practicing professionally as a lawyer, humorist and after-dinner speaker, and apple and potato farmer. In July, 1885, President Cleveland named him the Acting Superintendent of the Coast and Geodetic Survey

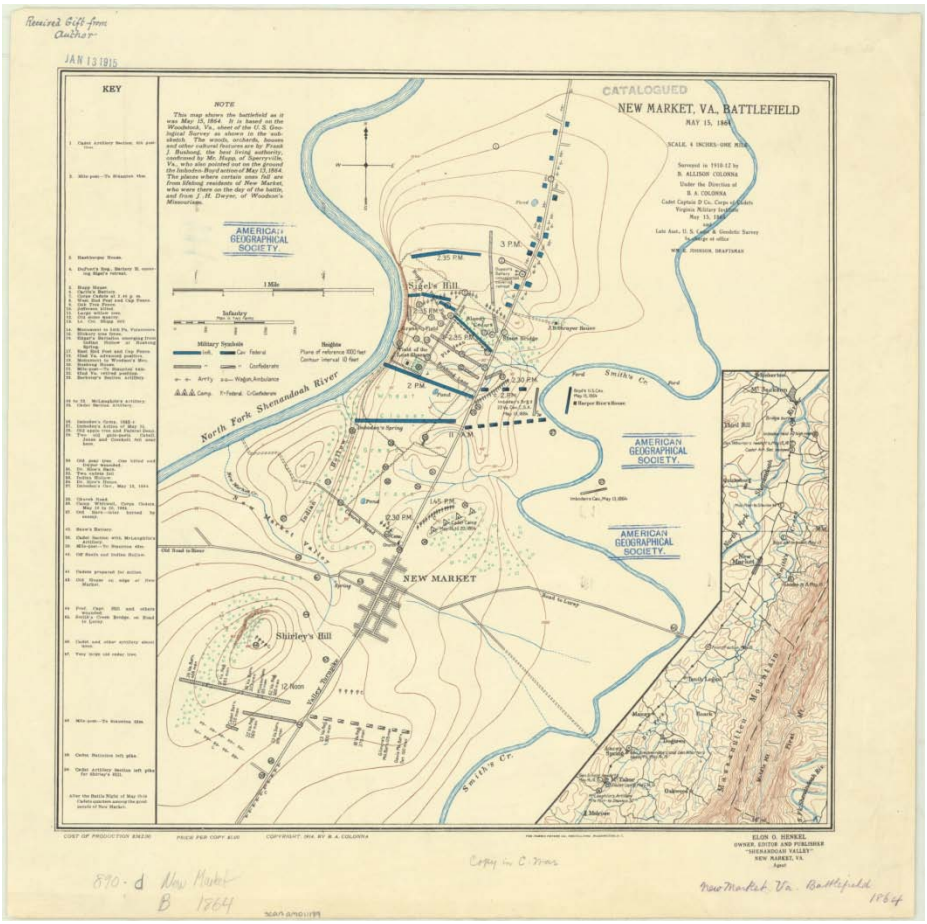
Thorn's very first order of business was to find someone capable of actually directing the Coast and Geodetic Survey. This was not an unfamiliar task; already in its history the Survey had survived the sudden deaths of Superintendents Hassler and Patterson, the long illness and incapacity of Superintendent Bache, and now the disgrace and removal of Superintendent Hilgard. Thorn had already met the headquarters staff—if only for three weeks as an IRS agent—and he made the first of a long string of very good choices. And so it was that Frank M. Thorn chose as Assistant in Charge of the Office a man who really was more of a partner in directing the Survey—Benjamin Azariah Colonna (1843-1925)

Colonna Crosses the Chesapeake from the Eastern Shore to Washington, DC

Benjamin A. Colonna was born October 17, 1843 on a farm in between the villages of Pungoteague and Craddockville, in Accomac County, Virginia, on the Eastern Shore of Chesapeake Bay. His family had emigrated from Europe to that area no later than the 1660s, and had remained there ever since. His grandfather was a farmer and a waterman, an apple brandy distiller, and also a first mate on one of the earliest steamships on Chesapeake Bay. The family owned slaves, and supported the Confederacy. Young Colonna went to Lexington in 1859, to attend the Virginia Military Institute. In May, 1864, Colonna and the other cadets of VMI fought in the battle of New Market, Virginia, causing the Union forces to retreat, although when they returned to VMI they found their barracks burned to the ground. Colonna became a Captain in the Confederate Army at General Johnston's headquarters in Atlanta, Georgia. Colonna was put in charge of two companies of Galvanized Yankees, one French-speaking and the other German-speaking,

[2] Barbara Schmidt and Leslie Myrick of the Mark Twain Project, UC Berkeley. See www.twinquotes.com

who had mutinied and murdered several of their own officers. He commanded these troops, in both French and German, which he had learned at VMI, in the Confederate retreat from Georgia to South Carolina, to eventual surrender near Charleston, in May 1865.



The Battle of New Market, Virginia in 1862
As re-constructed 1910-12 by Benjamin A. Colonna
And as surveyed by his son B. Allison Colonna

Colonna returned to an Eastern shore landscape decimated by the privations of the Confederacy and the Union blockade. He owed money to the state of Virginia for his VMI education, but there were little prospects for work. He spent several years teaching school, and continuing studies in civil engineering, looking for something better. In 1868, fate intervened. In March of that year, he wrote a letter to a friend, referring to himself in the third person.

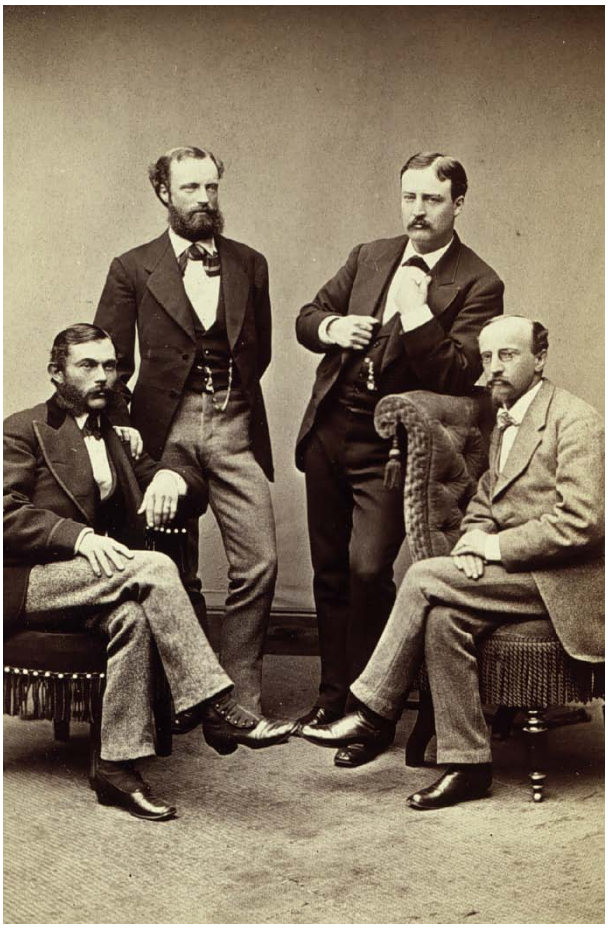
> "Mr. B.A. Colonna, the Village Schoolmaster, was turned over in the middle of the Creek, during the late equinoctial Gale and very unfortunately was bothered with an old man to save. He had to wet himself very thoroughly. Very fortunately for him, there happened to be a detachment of the U.S. Coast Survey on shore who, seeing his fine fix, soon rendered what service to him they could. One, I was glad to find,

> was a friend of the Cleary's and a schoolmate of Jim's. We formed a very agreeable acquaintance and he has almost induced me to enter the service if I can get an appointment as an assistant which he said would not be difficult to do. I believe I would like to do it as it seems to be a life I would like… Will you do me the kindness to inquire whether these appointments as Assistant in the Coast Survey can be obtained by an ex rebel and gain what other information you can on the subject. Wise very kindly offered to give me letters of recommendation and introductions to parties but I'd rather know what I am doing first."[3]

Entry to the Survey proved difficult, as did work in general, so Colonna worked another 2 years teaching school on the Eastern Shore and finding other work. He also fell in love with a 17-year old woman named Julia, for whom he was willing to abandon his life in the Survey, but she rejected his advances, leaving him broken-hearted.[4]

Finally, in the summer of 1870, he was hired as a chain-man on a Coast Survey topographic survey crew. His party chief soon found out how much education he had had, and promoted him to more valuable work. They also urged him to pursue a permanent career with that agency. His real entry into the Survey was under General Richard B. Cutts, surveying in Gloucester, New Jersey, on the Delaware River. He advanced enough to be sent to Washington to learn office work, following the field season. His career for the next decade or so was the classically varied work of the Survey: hydrographic surveying in Pamlico Sound, North Carolina on the steamer Hitchcock, then topography and hydrography on Long Island, NY. In 1876 he worked in Louisiana at the mouth of the Mississippi River on the Survey's series of Mississippi River charts. In 1877, he was detailed to San Francisco where he worked under George Davidson, who became a major friend and mentor. For the next few years he worked on the epic triangulation work of the Arc of the 39th Parallel triangulation system and the Davidson quadrilaterals. In 1879 he participated in the heliotrope signaling and angle measurements between high California mountain peaks that set a world record for line of sight distances in geodetic surveying. He published an article about his nine rigorous days on the summit of Mount Shasta which received wide distribution.[5] In 1882 he was surveying deep in Wyoming territory, and he participated in the second Transit of Venus experiments. 1883 found him on the east coast of Florida. In 1884, he returned to the Pacific coast for surveys in the straits of Juan de Fuca. It was there that his life changed.

[3] Letter Colonna to John Hanna, March 18, 1868. In Autobiography of Benjamin A. Colonna, 1903, Vol. 2, pp.13-14.
[4] Ibid., p. 18.
[5] Colonna, 1880.

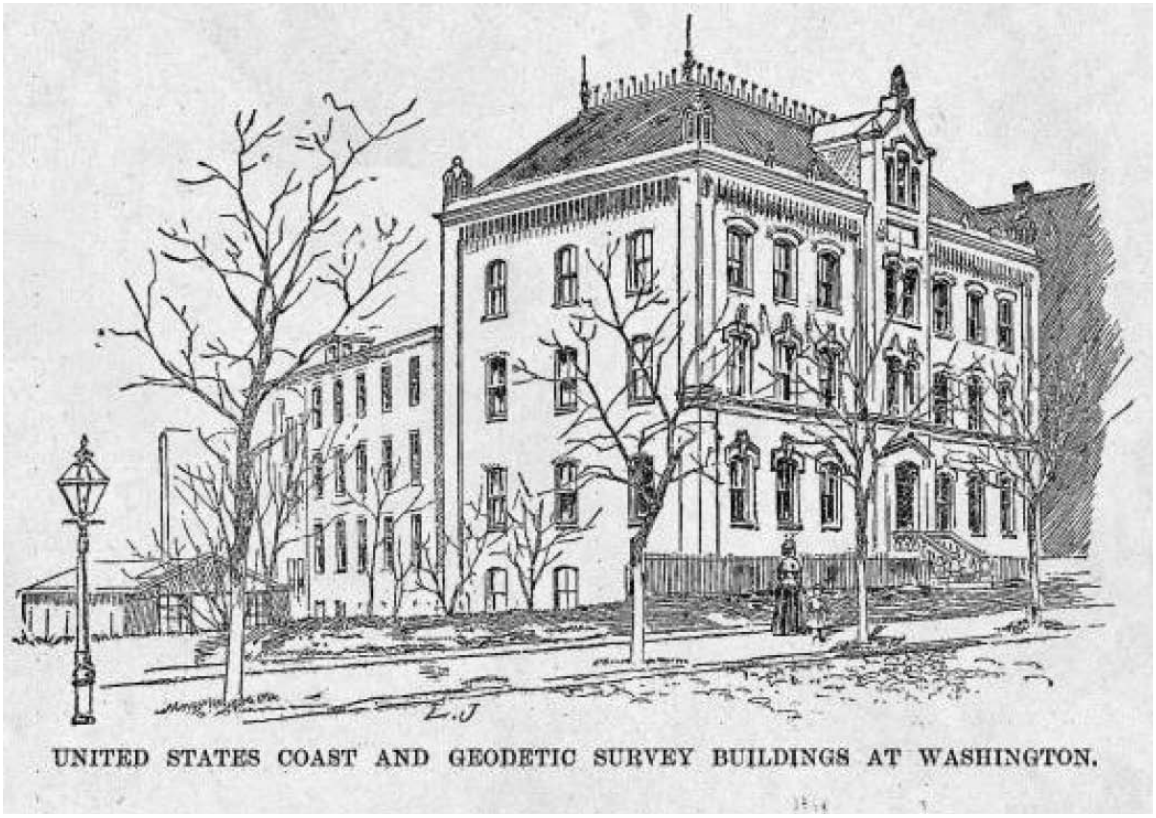


Louis Sengteller, E.L. Dickins, **Benjamin Colonna**, and unidentified man photographed in a studio in San Francisco, 1877 or later

On August 4, 1884, Colonna and a Survey party were skirting glaciers on the slopes of Mount Olympia, as part of a triangulation tie between Whidbey Island and Cape Flattery. Colonna slipped on loose scree, which precipitated an avalanche that carried him tumbling down the face of the mountain and partially buried him in rock and volcanic ash. As he related later, by chance he was wearing a very large Mexican straw hat that day. The other members of the party located him only because part of the hat was protruding from the rock rubble. Colonna was severely injured. He was rushed off the mountain and ferried to Vancouver, BC, to an excellent Catholic hospital, which probably saved his life. Colonna was paralyzed, losing all use of his arms and legs. Over a period of many months, he made a gradual and partial recovery from his injuries. He regained much mobility, but for the rest of his life he walked with a cane. His field work days were over.

And so it happened, in the fateful year of 1885, in the midst of the Allison Commission hearings, and immediately before Superintendent Hilgard's disgrace, Benjamin Colonna was ordered to Washington to take charge of the office work. The Survey headquarters on New Jersey Avenue were only a block from the Capitol, close

enough that even a partially disabled man with a cane could walk to give testimony before the Allison Commission.



The Survey's headquarters on New Jersey Avenue,
Harpers Weekly, October, 1888.

The Partnership of Thorn and Colonna

Thorn was briefly employed investigating the agency he was to lead. There are some indications that the stories he had heard about the disarray at the Survey caused him to display an initial hostility to many Survey personnel.[6] However it appears that he soon concluded that the problem personnel at the Survey were few and could be dealt with, while the majority of the agency's people were innocent of any of the charges thrown at them. At the same time, the agency had been in continuous operation for half a century at that point, spanning Hassler to Hilgard and the Civil War, and it had accumulated a large set of customs and procedures which could easily be considered questionable if scrutinized. Further, the outcry over questionable expenditures, whether justified or not, meant that money would become necessarily tighter, and all expenditures would be subject to much more rigorous auditing than ever before. In short, the Survey, to survive, would have to do more with less.

[6] Manning, especially 1975, takes this position.

Thorn was ignorant of almost every aspect of Survey operations, but he was capable and intelligent, and he was also a very trusted political ally of the President. Thorn chose Colonna, out of all the Survey staff, to become essentially the "real" leader of the Survey, at least initially. Clearly Colonna couldn't work outside the office, but it appears Thorn chose him for many other reasons. He was enthusiastic and smart, he had in little more than a decade worked in almost every scientific domain of the Survey, and he appeared to have the kind of management skills necessary to keep the staff satisfied and productive. And he was as different from Julius Hilgard as could be found in the Survey—a thoroughly native American scientist, and even an ex-Confederate, which could diffuse opposition in some quarter and enlist support in others.

Benjamin A. Colonna
Assistant in Charge of the Office

The partnership of Thorn and Colonna fell in place in the middle of the Allison Commission hearings. In the remaining year, various senior Survey scientists and others who had begun their scientific careers in the Survey, such as Cleveland Abbe, Alexander Agassiz, Marcus Baker, George Davidson, William Ferrel, Julius Hilgard Henry Mitchell, Charles S. Peirce, Charles Schott, as well as Benjamin Colonna, testified before the Commission. Superintendent Thorn never appeared once before the Commission. Assistant in Charge Colonna became the de facto spokesman to Congress, probably because he could not be tripped up by ignorance of the Survey's affairs, and his testimony wouldn't have to be corrected.

At the end of the Commission's time, it prepared a final report with recommendations to the Congress and the Executive Branch. There were two dangers the Coast and Geodetic Survey wanted to avoid: transfer of the Survey to the Navy one more time, or to be deposed geodetically, as it were, relative to the work of the US Geological Survey. The Survey won, on both issues. The Allison Commission advised against the transfer to the Navy, and they laid out a strong set of scientific reasons why the Coast and Geodetic Survey should continue essentially its entire plan of scientific research and publishing, although henceforth the major domain of topographic mapping in all non-coastal areas would be the responsibility of USGS. It helped that the USGS' leader John Wesley Powell, who was a close person friend of Julius Hilgard, had strongly supported the Coast and Geodetic Survey and its geodetic network as the foundation for USGS' mapping.

Thus, the Coast and Geodetic Survey survived the crisis year of 1885, and the Allison Commission finale of 1886. In 1887, the oldest threat to the Survey's existence came back in force: yet another maneuver by Congressmen on the House Committee on Naval Affairs to fold the Survey into the Naval Hydrographic Office.

The Survey Sails Close to the Wind

Colonna knew the Survey's work and he knew Congress; Thorn knew President Cleveland. Their strategic partnership was to work together in those disparate realms. What they did and how it worked is revealed in a unique document written by Thorn in 1903 in response to a query by Otto Tittmann, then the current Superintendent of the Survey. Tittmann was inquiring about a somewhat mysterious document, called "Historical Compilation U.S. Coast and Geodetic Survey". It was 16 pages long, listed no author, date, or publisher, and yet it had apparently served some vital purpose decades before. Frank Thorn replied from his orchard farm in Erie County, New York. His reply constitutes the very first memoir of any Superintendent of the Coast Survey and Coast and Geodetic Survey. Every previous Superintendent in history had died in office, except for Peirce and Hilgard, who resigned voluntarily and involuntarily, respectively. But neither of them ever wrote a memoir. Thorn's account is worth quoting in full. He had been a successful author, newspaperman, and speaker, and he could write a clear letter.

Orchard Park, NY
Jan. 31st 1903

Mr. O.H. Tittmann
Sup't U.S. Coast Survey
Washington, D.C.

Dear Mr. Tittmann:

The sixteen-page "Historical Compilation U.S. Coast and Geodetic Survey [1887?]" mentioned on pp. 86-138 of the "List and Catalogue of Publications" kindly sent to me, and a copy of which compilation I enclose herewith, was my work, prepared and used for a special purpose, I think early in 1888 instead of 1887. Notwithstanding its comparative and apparent insignificance, it was quite a factor in disarming executive prejudices and preventing the transfer of the Survey to the Navy Department.

When Hon. Hilary A. Herbert[7] was Chairman of the House Com. on Naval Affairs, he introduced and had referred to his own committee, a bill to accomplish that transfer, in perseverance of a long cherished plan of himself and President Cleveland. I promptly called at the Executive Mansion and asked the President if he favored Mr. Herbert's measure. "Yes" he replied; "You remember that I recommended the transfer in one of my first messages." When I told him that I believed the transfer would be injurious, he asked why and I told him that the experiment of Naval control of the Survey had been tried two or three times and always with unsatisfactory results. He was quite surprised and asked me if there was any published history of the matter. I told him that there was. He asked me to get it for him as he was liable to be called on or to act officially in the matter and he desired to act with full information. I told him that the history of that phase of the Survey's experience was scattered through various public documents from which I would compile the pertinent facts and submit them to him, in a sort of brief, together with copies of the documents from which the facts were compiled.

I had long known that the President had been predisposed to the transfer, not only by the shallow plausibilities of Sam. Randall[8], Mr. Herbert, Lt. Dyer U.S.N[9]. and others but by the fact that the Treasury Department was apparently acquiescing in the effort of the Department of his close friend, Sec'y Whitney[10] to capture our bureau. It seemed to me vitally necessary therefore, to correct his prejudice, not only by submitting a brief history of the Survey's experience with the Navy Dept. but by giving him an insight into its place of organization and the character, subdivision, variety and scope of its work succinctly stated and all fortified and supplemented by an argument as terse and emphatic as I could make it (with due regard to the official proprieties) in refutation of the sophistries with which our foes had, for three years, been filling the air. I paid for the edition of several hundred copies, one of which, accompanied by the original authorities, I sent to the President, who returned them to me about a year afterwards. It is, perhaps, worth noting that he did not, during his second term, renew his recommendation for the transfer of the Survey.

Mr. Colonna and I decided, in the meantime, not to await the President's conclusion. Copies of the compilation were sent to several of the Senators and Representatives, and Colonna read it to various members of Mr. Herbert's Committee on Naval Affairs, and the result of that form of missionary work, was the smothering of

[7] 2nd District of Alabama (Democrat)
[8] 3rd District of Pennsylvania (Democrat)
[9] An officer in the Hydrographic Office of the Navy
[10] Secretary of the Navy

Chairman Herbert's measure by his own Committee, as several of its members promised in their interviews with Colonna.

That was one of several occasions when Colonna's service to the Survey, in preserving its autonomy, was inestimable. The friendship and unquestioning confidence of certain Senators and Representatives enabled him to accomplish more at the Capitol, than any other member of the Survey, to prevent its dismemberment or transfer. At the White House end of the line the man closest to the President was an advocate of the appointment of a certain unsparing and unscrupulous naval critic of the Survey, to its Superintendency as my successor.

I doubt if anybody but Colonna and myself knew how close to the wind the Survey sometimes sailed, or how desperately vicious, and even villainous, were some of the agencies employed to wreck it—and all those agencies could have been placated at any time by my consent to debauch the service by the appointment or promotion of certain rascally parasites of Randall, Chenowith[11] and Co.[12]

As you will observe, probably not more than one fourth of the pamphlet is a compilation—the residue being such a statement and argument as seemed to me best calculated to appeal to the layman instead of the scientist.

Yours truly,
F.M. Thorn

"…it was in fact a Geodetic Survey"

If Thorn's memoir was unique, so also was his Historical Compilation. In a short publication, he collated and described a number of difficult and confusing campaigns to transfer the Survey to the Navy, the dismal outcomes of the transfers that succeeded, along with Thorn's understanding of the work of the Survey, with particular reference to publishing what he called "a perfect map". That that was the arena of contention about which agency should produce hydrographic charts, and also, I would submit, the objective of "a perfect map" is an apt descriptor for the tenure of Superintendent Thorn. In many ways, his short tenure can now be seen as another golden age of Survey cartography, akin to those under Bache and Patterson.

Thorn situates the entire enterprise of the Survey in its fundamental geodetic foundations:

"In pursuit of the original plan of 1807 and of the completer plan of 1843, and to avoid disgraceful inferiority and imperfection of its results, the operations of the Survey were always—except when withdrawn from civilian control—conducted in conformity

[11] James Q. Chenowith, 1st Auditor of the Department of the Treasury. His actions are described in the chapter on Superintendent Julius Hilgard.
[12] See Manning, 1975 and 1988, for accounts of these initiatives—although Manning's analysis and conclusions depart significantly from my own.

with the requirements of geodesy—it was in fact a Geodetic Survey. The transcontinental operations were not only strictly related to the survey of the coasts, (as essential to the harmony of the measurements along the Eastern and Western shores, and as affording a most valuable contribution to that knowledge of the form of the earth and its local variations which is essential to the accuracies of the survey of the coast), but incidentally they supply to the traversed states accurately located points—otherwise practically unobtainable by them—upon which to base their own topographical or geological surveys, for the construction of accurate County or State maps. It will also provide part of that framework without which no accurate map of the United States is possible. Upon that arc has already been achieved some of the best work ever done in accuracy of base-measurement, accuracy and range of observations and area of geometrical figures, and at much less than the cost of similar, but less notable, work abroad. That the enterprise is either premature or extravagant will hardly be urged in face of the fact that Europe presents not a single transcontinental arc of triangulation, but a complete net-work covering every country except Turkey and a portion of Russia, and that even in remote and mainly uncivilized India, a superb work of triangulation ten times as extensive as our transcontinental arc has already been completed".[13]

The Compilation is a combination of excerpted text from a variety of historic documents, Thorn's own commentary, such as the passage just quoted, and finally, materials submitted by Colonna or other Survey personnel to the Allison Commission. One key passage, from one of Colonna's sessions before the Commission, summarizes the kinds of field work underway in Thorn's era.

"The field work of the Geodetic Survey is in eight different lines, all but one (the fifth) of which are necessary to the production of a perfect map. These divisions are:

"First. *Triangulation*, including base measurements, by means of which distances between prominent points are made known.

"Second. *Astronomical observations*, by means of which directions of all measured lines are made known, and also the locations of points on the earth are made known…

"Third. *Leveling*, by means of which the heights of objects above mean level of the sea are made known.

"Fourth. *Tidal observations*, for determining the mean level of the sea, from which heights are reckoned; also for predicting the rise and fall of tides for the use of navigators and others, and also for the reduction of soundings taken at any time to what they would have been if made at low water.

"Fifth. *Gravity observations*, for determining the density of the earth.

[13] Thorn, Historical Compilation (1887), p. 8.

Sixth. *Topography*, or the picturing by conventional signs of all the surface features of the land, its elevations and depressions, its streams, roads, canals, its forests, plains and mountains, its towns, fields, etc.

"Seventh. *Hydrography*, by means of which the configuration of the bottom of the sea, lakes, and rivers become known; also physical hydrography which makes known the character of rivers, tidal, and ocean currents, their effects in producing progressive or periodic changes in the configuration of the bottom.

"Eighth. *Magnetic observations*, from which we learn the direction in which the compass needle points, the changes in the direction, the intensity of the magnetic force, which directs the needle and the variations of this force, and thus get material to foretell the changes of direction to which the compass needle is subject, and the variations of the force directing it.

"The order in which these operations are carried out is not an arbitrary but a logical one, and in this logical order the hydrography comes last."[14]

In fact, although the progression from triangulation to publication ready material is generally as Colonna stated, hydrography as such didn't necessarily come last, but making hydrography appear last was a key argument of the Survey to deflect the latest initiative of the Naval Hydrographic Office to take over the Survey. The Navy stressed that they were capable of hydrography; the Survey countered that hydrography was dependent on the full array of geodetic sciences that necessarily preceded the hydrography.

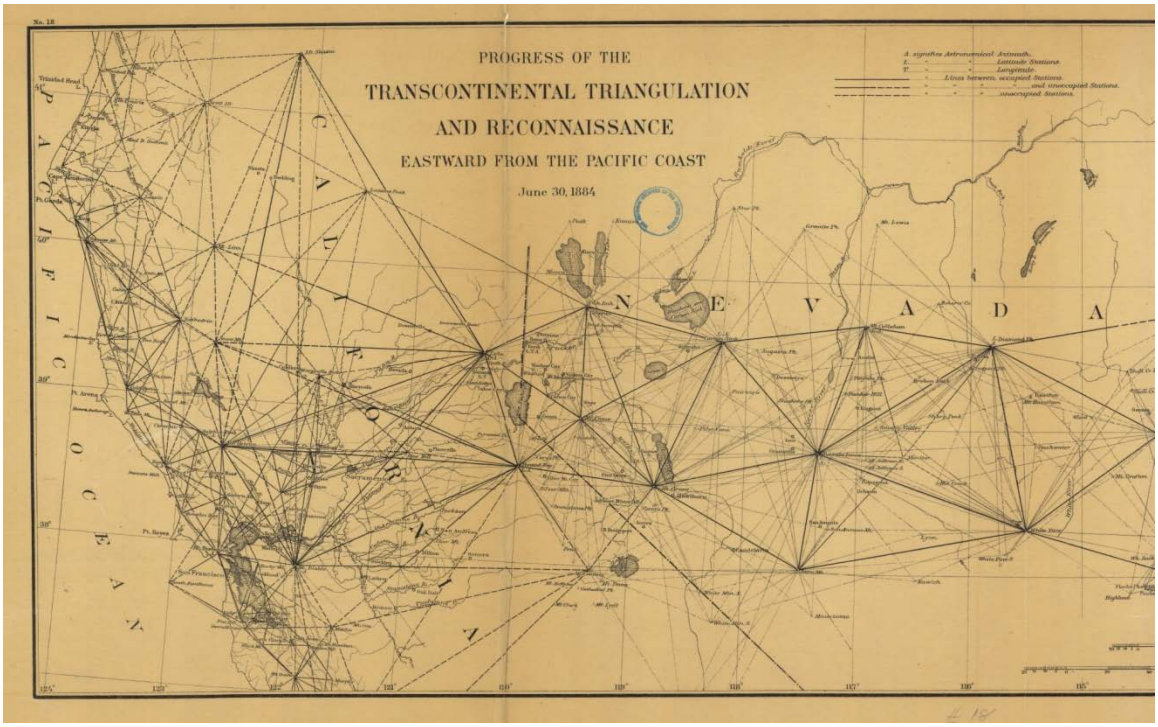
But in any case, Colonna's progression of the disciplines and their timing in the map production process can provide a useful framework to discuss the actual achievements of the Survey during Thorn's tenure, as opposed to discussing the work accomplished division by division, as had been done in earlier chapters. The Hilgard/Thorn era of the Survey was unparalleled for the turmoil within the agency, with the Superintendent forced out, several key officers fired and then re-instated, retrenchment of budgets, outside scrutiny of expenditures, significant losses of salary to Survey personnel, and so on. It is a wonder that the Survey was able to accomplish as much as it did.

Triangulation

It may be argued that the Arc of the 39th Parallel triangulation network exercise in the west brought Survey geodesy to a whole new level, literally and figuratively. The combination of basin and range topography, the existence of isolated peaks visible at great distances, and the occasional atmospheric clarity that allowed those observations, led the Survey to triangulation observations at distances never before accomplished anywhere. Assistant Colonna had himself been a participant in the great triangles in

[14]Ibid., pp. 11-12.

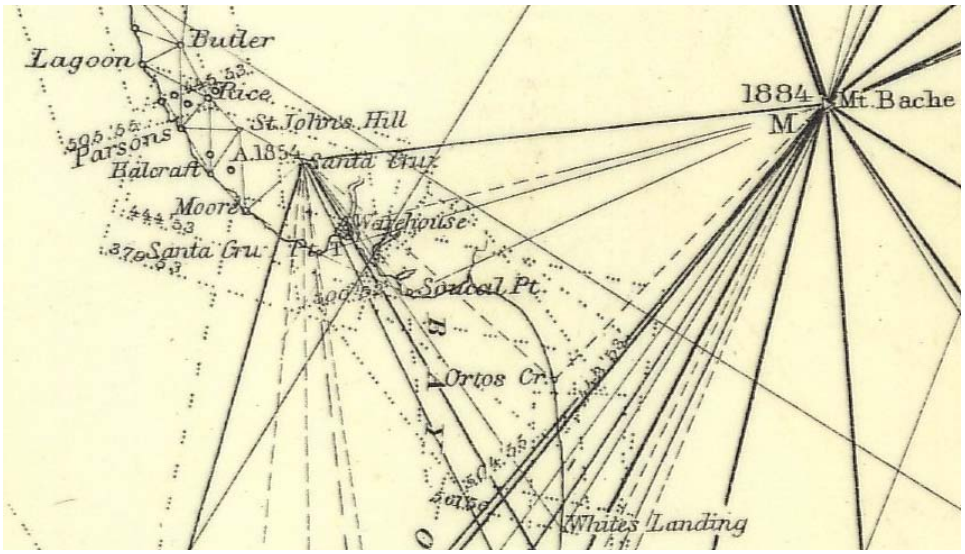
California. But the potential of great distances and areas positioned also made it paramount that stations were chosen well. Much thought and experimentation on this matter was condensed in Charles Boutelle's treatise "On Geodetic Reconnaissance", which was published, ironically, at the same time that Boutelle was first relieved of his post, and then later on, after he petitioned for a Congressional hearing, cleared and restored to his position in the Survey. His treatise summarized what the Survey had learned in the west. "It is not intended to supercede any portion of Appendix No. 9, Report of 1882, on the field work of the triangulation, but rather to enlarge and illustrate that portion of it which treats of Reconnaissance, by examples drawn from actual cases occurring in the usual routine, and by bringing out very fully the principles, theoretical and practical, which should govern in carrying on this very difficult, responsible, and laborious portion of Coast and Geodetic Survey duty. No department of professional labor calls for the exercise of a higher order of ability, or better repays thorough execution."[15]



A portion of Sketch No. 18, Annual Report for 1884,
Show the combination of reconnaissance triangulation and
primary triangulation along the 39th Arc Transcontinental Survey

Once the primary network was well established, Survey crews could return for secondary and tertiary triangulation of smaller areas, generally in close conjunction with topographic and hydrographic mapping. An example of the latter was the triangulation in the vicinity of Santa Cruz, California, in 1884 and 1885.

[15] Boutelle, 1885, App. No. 10, P. 469.



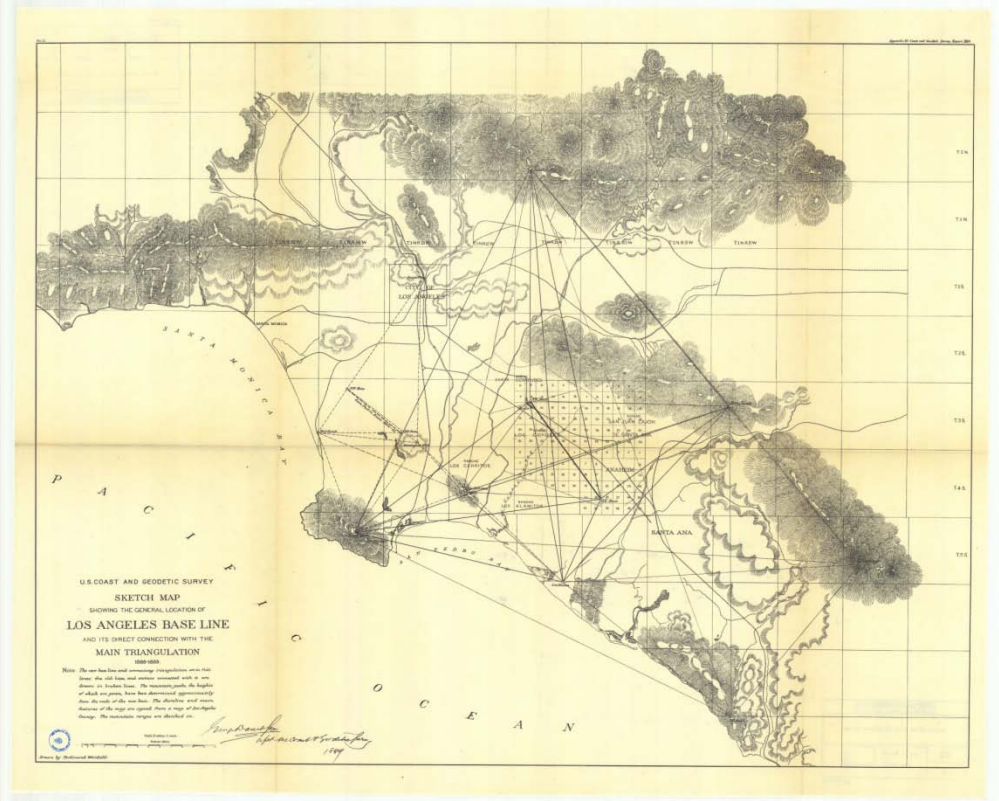
A portion of Sketch No. 10, Annual Report for 1885,
showing secondary and tertiary stations in the vicinity of Santa Cruz California

.

George Davidson's camp by the San Lorenzo River, outside Santa Cruz
in a grove of California live oaks
From Benjamin Colonna's Photo Album

The other essential exercise in triangulation is the measurement of highly accurate base lines, at appropriate places and intervals. George Davidson organized the enterprise of the Los Angeles base line, which set new standards for precision in measurement in the Survey.[16]

[16] Davidson, 1889, App. No. 9, pp. 217-231.



The Los Angeles Base Line, 1889

As usual, the baseline was measured on the flattest place possible, and then tied in to triangulations of surrounding high peaks.

Astronomical Observations

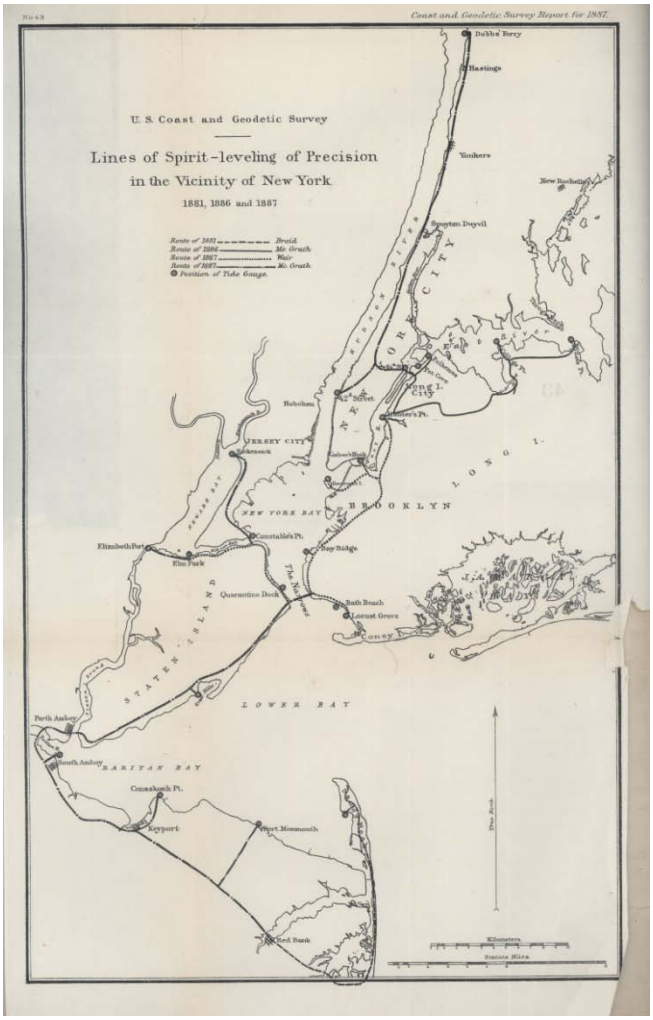
During Thorn's tenure the Survey certainly continued making observations, but the more important development was the ways in which the Survey's work in astronomical positioning and deflections of the vertical and other aspects of geodesy were increasingly situated in larger international scientific context. Charles S. Peirce's gravity research was noted in Europe, and that fact was noted in the United States. The Survey had joined the International Geodetic Association, headquartered in Berlin, and George Davidson had attended the Association's annual meeting in 1888, possibly at his own expense, due to the difficulties with Survey funding and audits for improper expenditures. Finally, as one of many indexed publications the Survey published under Thorn, J. Howard Gore published his massive Bibliography of Geodesy as an appendix in the annual report. As Thorn noted, strategically, in his introduction:

"My own conviction of the propriety of Professor Gore's attitude was so clear that I could not, without a conscious disregard of duty, have declined the proffer of his manuscript to this Survey, for preservation and publication among the scientific appendices to its Annual Report, and so assuring, without cost for preparation or compilation, appropriate association of the recognized American Bureau of Geodesy with

a complete Bibliography of Geodesy, American, in inception and authorship and the first work of its kind".[17]

Leveling

The Survey created various new networks of "spirit leveling of precision" which were tied into tide station networks and the triangulation networks to allow characterization of the movements of water in tides and currents at a scale and precision never before achieved. One of the most signal exercises in Thorn's era were the tide station and spirit levels of precision networks around New York Bay and Harbor.



The network of tide stations and lines of spirit-leveling of precision in the Vicinity of New York, 1887

[17] Thorn, 1887, App. No. 16, Intro., p. 313.

Many of the tide stations had been in place since Bache's day, others were installed under Thorn. But the lines of leveling of precision allowed heights of the tide stations to be determined with much greater accuracy relative to the Survey's sea level datum for New York Bay and Harbor.[18]

The much more accurate data resulting from the more precisely situated tide stations then, in turn, allowed Henry Mitchell, and later his assistant Henry Marindin, to characterize the tide and current flows in and out of the harbor as had never before been possible. This allowed Mitchell to establish the critical roles of the ebb tide flows of the East River, bringing great quantities of sea water from Long Island Sound into the Bay, and the roles of these ebb flows in keeping open navigation channels in the Bay. His research had dramatic impact on the receptions of major alterations that had been proposed for the Bay. The story is summarized in Henry B. Well's unique lauding of the imperiled Survey, published in 1888 as a special four-page Supplement to the journal Harper's Weekly.

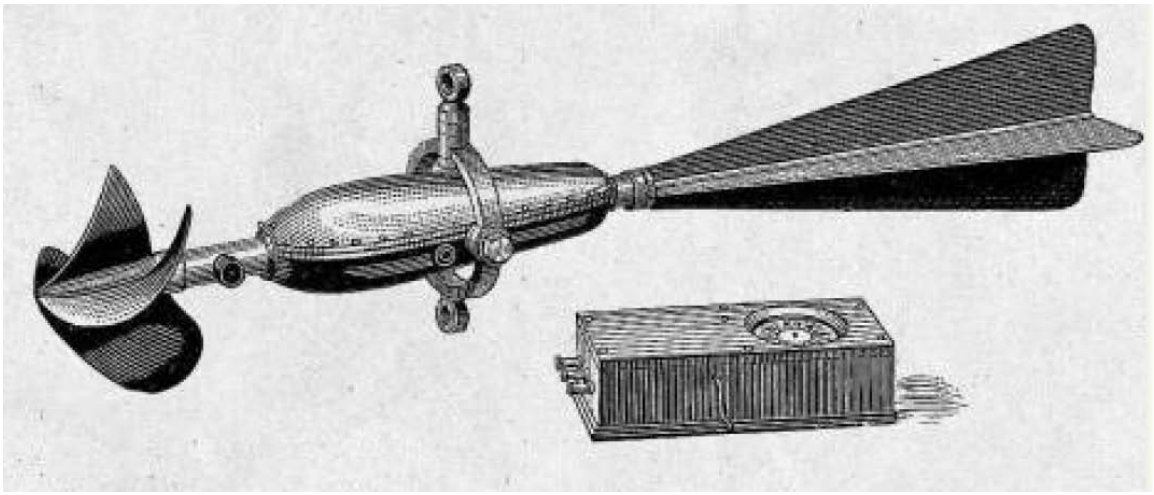
"Another interesting feature of the work is the observation and study of currents in relation to channel-scouring, shoal-building, and the like, under the immediate supervision of Professor Henry Mitchell, a veteran assistant in the Coast Survey, and at the same time one of the Mississippi River Commission. Few indeed are the men who are engaged in our foreign trade, whether as merchants or sailors, who are not indebted to Professor Mitchell. Again and again has his wise counsel prevented irreparable harm to our ports. Take a case in point. Some time before the Brooklyn Bridge was projected it was proposed to close East River by a broad dike, and thus unite New York and Brooklyn. The New York Chamber of Commerce, wise in its generation, submitted the matter to the Coast Survey. Professor Mitchell informed them that if this were done the depth on the bar at Sandy Hook would diminish some four feet. The project was abandoned in consequence. The damage which would have resulted to the prosperity of New York and the adjacent cities in one year, from such a mistake, would have exceeded the entire cost of the Coast Survey from its inception to the present day.

"Professor Mitchell answered this question as he did on theoretical grounds. The entrance to New York Bay is but an inlet, a break in the littoral cordon which reaches from the end of Long Island down to Florida, and of which Coney Island and Sandy Hook are dry parts. Why is it that entrance has and maintains a depth almost unique among such harbors the world over? Why is it that New York Harbor is prone to remain open to commerce when harbors far to the south are closed by ice? If the rivers which flow into it were the only scouring cause, New York would be a barred harbor with comparatively little water on the bar. Rivers aid little in this work. The lighter fresh-water flows over the denser salt-water, and does not reach the bottom. It is like trying to dig a hole in the ground by shoveling in the air. The heavier salt-water is the shovel that reaches the bottom and does the work. More salt-water must pass out over Sandy Hook bar on the ebb tide than entered it on the flood tide, and from Long Island Sound through

[18] Before the vertical networks of the early 20th century, there never was a uniform "seal level datum" fo the Atlantic coast. Sea level datums were established for major ports separately. Dave Doyle, Chief Geodetci Surveyor, National Geodetic Survey, pers. comm.. 2009.

East River this surplus must come. It is the low freezing-point of this excess of salt-water, and the rapid change of water it produces, which kept the port from being closed in by ice. What an escape was it that that dike between New York and Brooklyn was not built!

"Not very long since one of the employés in his field party, Mr. Eugene E. Haskell, invented, in conjunction with Mr. Edward S. Ritchie of compass fame, a wonderful machine. It could be placed in any reasonable depth of water, and would record at any place with which it was connected the exact velocity and direction of any current which might exist where the machine was. A careful series of experiments with this machine showed that the ebb-tide exceeded the flood-tide through East River by 448 millions of cubic feet. Every position taken by Professor Mitchell on theoretical grounds was confirmed by direct experiment."[19]



Haskell and Ritchie's Current Meter
Harper's Weekly, Supplement, October 20, 1888

Mitchell's triumphant success in defeating a plan to dike the East River was the legacy of many years of data accumulation and much pondering about dynamic tidal systems of the Bay.[20]

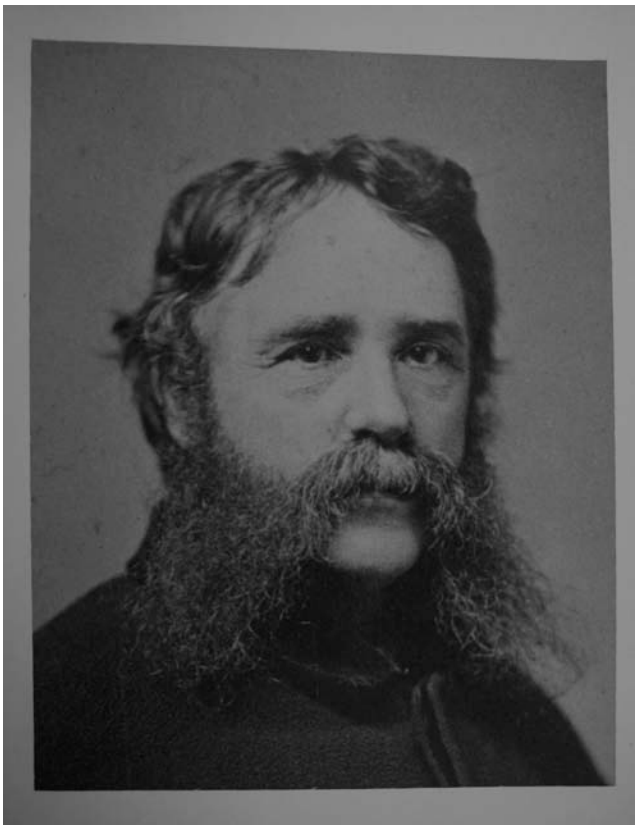
Tidal Observations

As the previous example made clear, it is hard to separate tidal observations from many other elements of topography, hydrography and leveling and, for that matter, from geodesy in general, as all these matters are closely connected to the determination of the geoid and evaluation of other phenomena in relation to that. The major developments in

[19] Henry Well,s 1888, p. 806.
[20] See Mitchell, 1886, App. No. 13, and 1887, App. No. 15.

Thorn's tenure were continuation of major initiatives combined with the departure of major Survey scientists closely associated with those same initiatives.

Some time during Thorn's era, Henry Mitchell departed the Survey and his role as Chief of Physical Hydrography. It is not entirely clear when this happened, but the fact that he is listed in the Alphabetical Index for the annual report of 1888, and is missing from the same index for 1889, is suggestive. It is also unclear why he left. Manning says he was driven out by Thorn: "When Henry Mitchell, the hydrographer and harbor expert, showed obvious unhappiness at Thorn's presence in the Coast Survey, the superintendent mocked both Mitchell's technical learning and his personal mannerisms. Mitchell soon resigned".[21] However, Manning cites no source for this story, and many elements of his discussion of both Thorn and Colonna do not ring true.

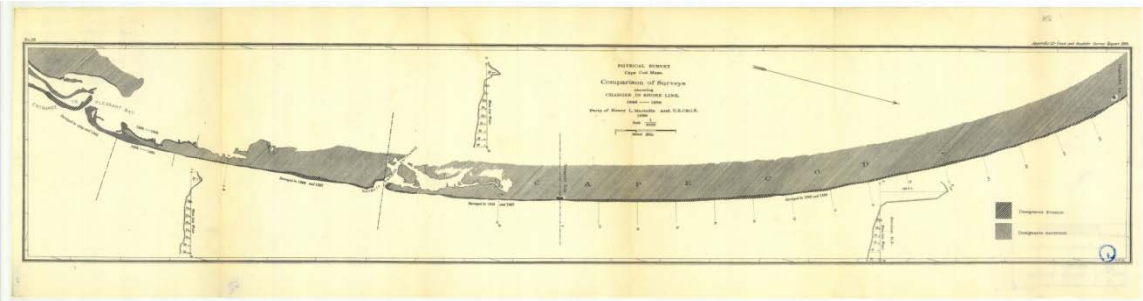


Henry Mitchell, Chief of Physical Hydrography
an undated photograph

In any case, Henry Marindin, Mitchell's assistant, now became Mitchell's successor, in completing comparative studies of hydrographic changes in areas pioneered by Mitchell. Hence, in 1889, Marindin analyzed "Encroachment of the sea upon the coast of Cape Cod, Massachusetts, as shown by comparative surveys". As he noted: "with the data obtained by the party of Physical hydrography in my charge during the

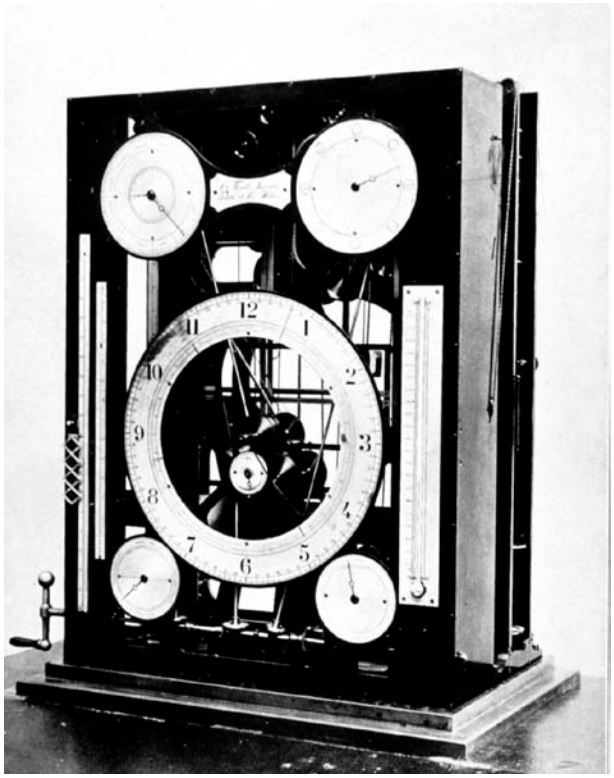
[21] Manning, 1875, p. 190.

season of 1887 and 1888 on Cape Cod, we are now able to make comparisons and show the changes which have taken place in the shore and bluff lines on this part of the Cape since previous surveys, and thus add to our knowledge of the physical history of the Cape, the study of which was initiated by Assistant Henry Mitchell in 1871." [22]



Changes in Shore Line, Cape Cod, by Henry Marindin
Figure No. 28, Annual Report for 1889

The other major change in the Survey related to tidal observations and related matters was the long-delayed completion of William Ferrel's Tide Prediction Machine. Ferrel had completed the fundamental concept and design of the machine in 1881-1882.[23] The machine was built almost entirely by Ernst Fischer and his staff in the Instrument Division, a process that took half a decade.



[22] Marindin, 1889, App. No. 12, p. 403.
[23] Ferrel, 1883, App. No. 10, pp. 253-272.

Gravity Observations

Colonna noted gravity observation as the one type of field activity not necessary to the production of "a perfect map". Nevertheless, gravity work continued and expanded under Thorn. This was at no little risk, as Charles S. Peirce's gravity research had been singled out for scrutiny as "impractical science" both by the Treasury department auditor Chenowith, and various members of the Allison Commission. Peirce was a target in part for his idiosyncratic personal behavior, and also for his refusal to back down or become submissive in response to the serious charges leveled against both him and his research. Peirce had already acquired an international reputation for his research in gravity, several branches of mathematics, and logic. He was also acquiring a national reputation based on his eccentricities, particularly in relation to the ostensible duties of federal employees. At the nadir of the Chenowoth[24]/Allison Commission scandals for the Survey, Peirce actually wrote a letter of resignation to the Secretary of the Treasury, which he gave to Thorn. Thorn saved Peirce's career at the Survey by refusing to pass the letter on to the Secretary. Thorn also expressed a certain understanding and appreciation for Peirce in a letter in which he paid him a high compliment, given his career as a successful writer of humor. Thorn noted that Peirce was good at turning "the humdrum routine of official intercourse into a series of lively episodes".[25]

Peirce's reputation concerning gravity research was based on his rigorous research in the imperfections in the mechanisms of swinging pendulums and their impacts on the resultant data on gravitational attraction at the instrument's site. His greatest problem in extending his research was that he was unable to design and acquire pendulums and their mechanisms that were sufficiently accurate for his rigorous purposes. Nevertheless, his conceptual schema for the kinds of research he thought useful and necessary was as big as the country. As an anonymous contributor to Science noted after interviewing Peirce:

"Mr. C. S. Peirce explained some of the errors still needing correction in pendulum observations, particularly such as were due to the flexure of the pendulum. He presented the outline of a scheme for a gravitation survey of the entire country, indicating the position of points in the eastern portion of the country which he thought most desirable to occupy, in which the stations would be about two hundred miles apart, regions of geological disturbance avoided, but their sides occupied, together with the summits of the higher mountains. Seven or eight stations could be occupied in a year, and

[24] The Treasury Department Auditor referred to previously
[25] F.M. Thonr to C.S. Peirce, March 3, 1887, in C.S. Peirce Papers, Houghton Library, Harvard University. Described in Manning, 1975, p. 189.

thus a series of curves secured which would give us the form of the geoid; i.e., of the surface beneath the continent where the force of gravity was uniform."[26]

Peirce's schema for a network of gravity stations echoes and extends notions within the Survey, going back at least as far as 1871, with Charles A. Schott, to create a networked system of observatory sites at relatively evenly spaced intervals, in order to determine magnetic declinations for the nation.

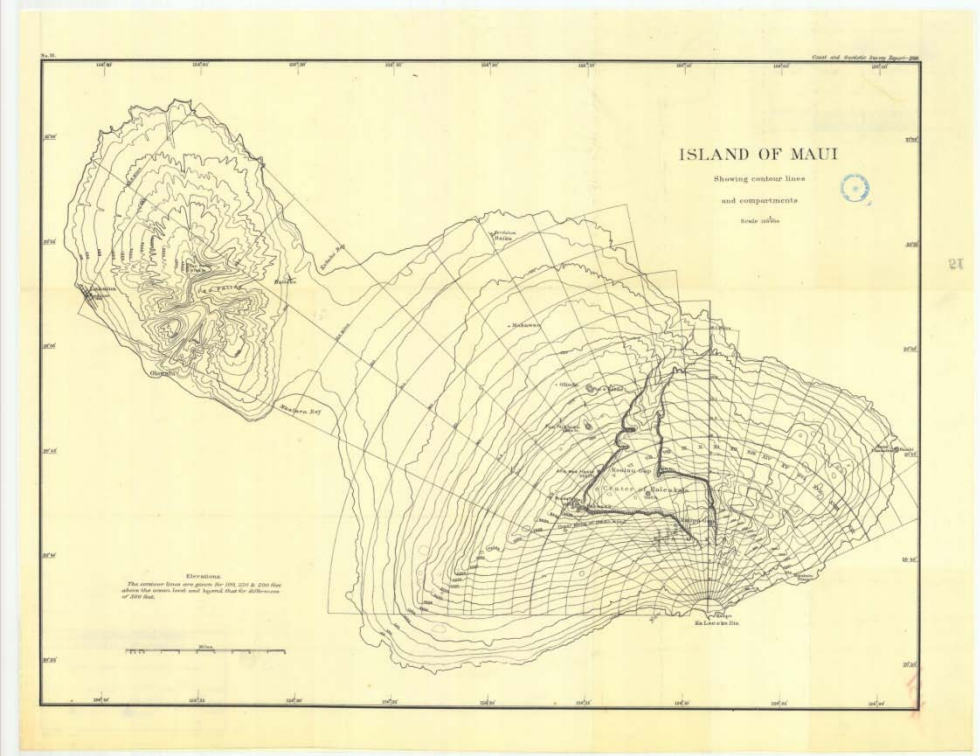
Charles A. Schott's schema for magnetic observatories
From his Smithsonian workbook, dated 1871
LOC Manuscripts Division

In the early stages of Peirce's gravity research, he utilized the unique situation of Hoosac Mountain in western Massachusetts, which has a railroad tunnel running through it, to swing his pendulums at the top of the mountain and deep inside it. Peirce's experiment posited the tiny difference between gravitational attraction between the two sites, allowing for compensation for the mass of the mountain, would allow Peirce to "weigh" the earth. Unfortunately, the imperfections in the pendulums precluded the accuracies Peirce needed to accomplish this. Nevertheless, Peirce's concepts for measuring gravitation relative to mountain masses were extended in other research within the Survey.

The second major gravity researcher in the Survey was Erasmus Darwin Preston. During the Thorn tenure, Preston made a long and productive research trip to the

[26] Science, October 24, 1884, P. 397.

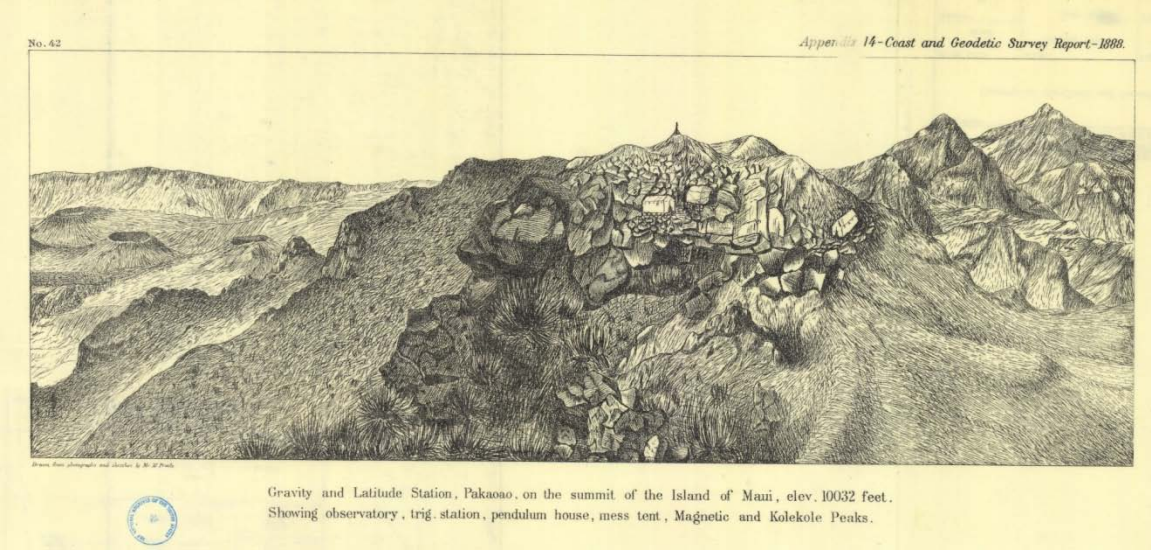
Hawaiian Islands, entirely funded by the Kingdom of Hawai'i. As Preston noted, his journey to make latitude and gravity measurements really had its origin in 1883, when two members of the United States Solar Eclipse Expedition stopped in Hawai'I to determine the force of gravity at a station established by a French scientist, De Freycinet, in 1819. However, their determination of latitude at the station differed significantly enough from other determinations nearby, that the scientists considered the reason for this to be deflection of the vertical by the volcanic mountain masses of the island. "Professor W.D. Alexander, the Surveyor General of the islands, at once conceived the project of having a number of latitudes of precision determined, which should not only include Maui, but all the larger islands.. The scheme proposed by Professor Alexander contemplated the occupation of fourteen latitude stations, of which three were on Kauai, four on Maui, and four on Hawaii. But as the object of the observations was the determination of the deflections of the plumb-line, and this depends on the density of the mountains, it was thought advisable to supplement the latitude work by some measurement of the force of gravity. Therefore the original plan was extended so as to include pendulum observations on the summit of Haleakala, Maui, at a station near the sea-level of the same island and at Honolulu."[27]



The Island of Maui Figure 51, Annual report for 1888
Pendulum stations were at Lahaina, extreme west of the island,
and adjacent to the summit caldera on Haleakala

[27] Preston, 1888, App. No. 14, p. 472.

Preston's research extended and enlarged the cooperation between the Coast and Geodetic Survey and the Kingdom of Hawai'i, which actually began in 1871, when the Survey had loaned a baseline measuring apparatus and other geodetic instruments to the newly formed Hawaiian Government Survey. The Hawaiian Survey used the equipment to establish the first baseline, on the island of Maui[28]. Collaboration between these two Surveys continued after American annexation of the islands, including the geographic and linguistic research of W.D. Alexander's important gazetteer of Hawaiian place names published in the Survey's Annual Report for 1902[29]. Further, Preston's photography and engravings of his stations and different locations on the journeys to them still serve as critical data for environmental changes in the Hawaiian Islands.

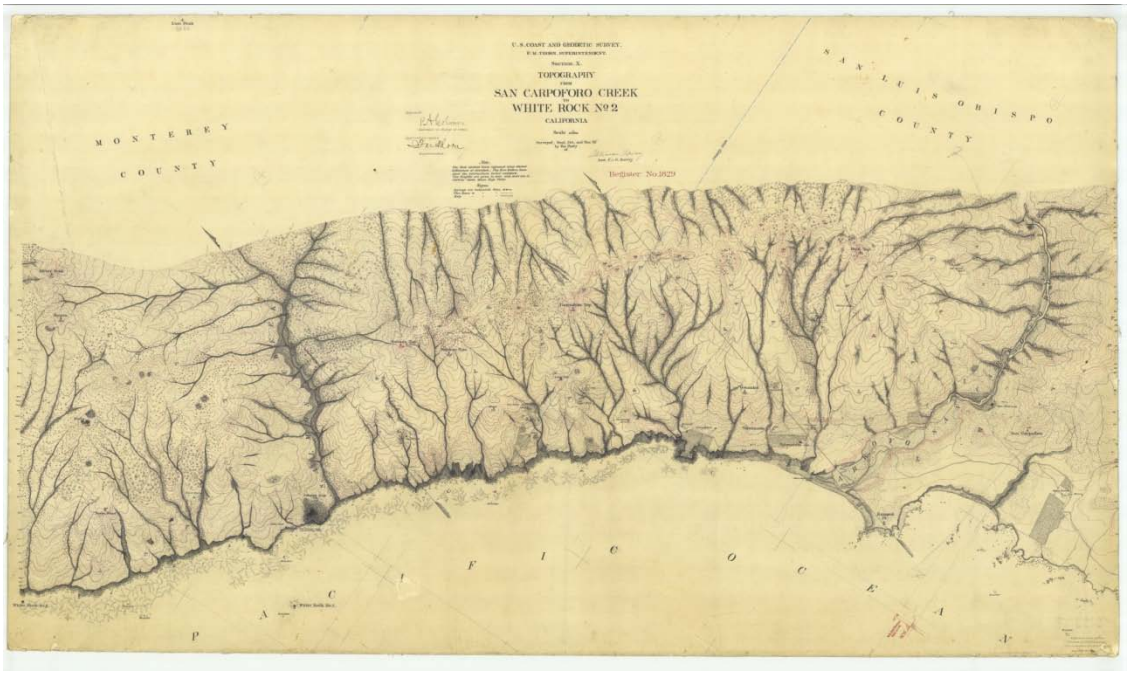


Gravity and Latitude Station at Pakaoao, on Haleakala
Figure No. 42, Annual Report for 1888

Topography

Certainly the greatest impediment to progress in topography (and also hydrography) during Thorn's tenure was the financial and budgetary scandals that engulfed the Survey under Hilgard. Scrutiny of the field work per diem salaries, and the funding of field work in general exacted a heavy toll. Since Survey personnel spent so much time in extremely isolated areas, and since they needed great quantities of specific and often expensive supplies, the only realistic way to secure their supplies was to give personnel the funding they needed in advance. This situation could lead to embezzlement and inappropriate purchases, but at the same time there wasn't any realistic alternative, although the Allison Commmission and Chenowith both demanded changes. But Thorn did what he could, and what was necessary to hold down expenses and produce more with less, and so field work revived, and even flourished.

[28] Lyons, 1903, p. 9.
[29] Alexander, 1902, App. No. 7: 367-



T-1829 Big Sur Coast of California, San Carpoforo Creek to White Rock No. 2
Surveyed by Assistant Stehman Forney, approved by Colonna and Thorn 1887

Possibly in response to the upheavals in field work, although this is not certain, the Survey under Thorn prepared a remarkable document, "Instructions and Memoranda for Descriptive Reports to Accompany Original Sheets". It is one of the summary intellectual achievements of the Survey, a paragon of the state of geographic, ethnographic, and ecological literacy of Survey scientists in the era. It was organized by the finest field scientists in the Survey: "Pursuant to the recommendations made in the report of C.O. Boutelle, B.A. Colonna, Henry Mitchell, Lieut. Commander W.H. Brownson, U.S.N., E. Hergesheimer, and H.G. Ogden, Assistants, U.S. Coast and Geodetic Survey—a board to whom the subject matter was referred—each topographic or hydrographic sheet hereafter deposited in this office will be accompanied by a descriptive report relating to the locality surveyed, and embrace such topics relative to that locality as are mentioned or suggested in the subjoined schedules of topics, to the compilation of which the members of the board above mentioned and Assistants Davidson, Rodgers, Lawson, Lieut. J.W. Hawley, U.S.N., and Lieut. G.H. Peters, U.S.N., have contributed."[30]

The basic point of the Instructions and Memoranda is to induce its users to notice *everything important* in the landscape and seascape as regards to the place, and to crystallize that knowledge in a narrative that best presents the information in a way conducive to preparing charts and coast pilots and sailing directions as the best aids to

[30] Thorn, 1887, App. No. 11, p. 211.

navigation possible. There are long lists of specific types of questions that can be asked and answered, differentiated for topographic or hydrographic sheets. One example each from each domain will give the flavor and rigor of the questions asked, and the rigorous understanding of the landscape and seascape necessary to answer the questions.

Schedule of Topographic and Physical Subjects

7. Does the coast recede, and at about what rate? State authority for rate given. What becomes of eroded material? Are there evidences of emergence or subsidence of shores, and what are they? If there are salt marshes, are they reclaimable? What would be the length of dike needed, and what is the ratio of dike to drainable area? Can the water be sunk by sluices, and how much?

Schedule of Hydrographic Subjects

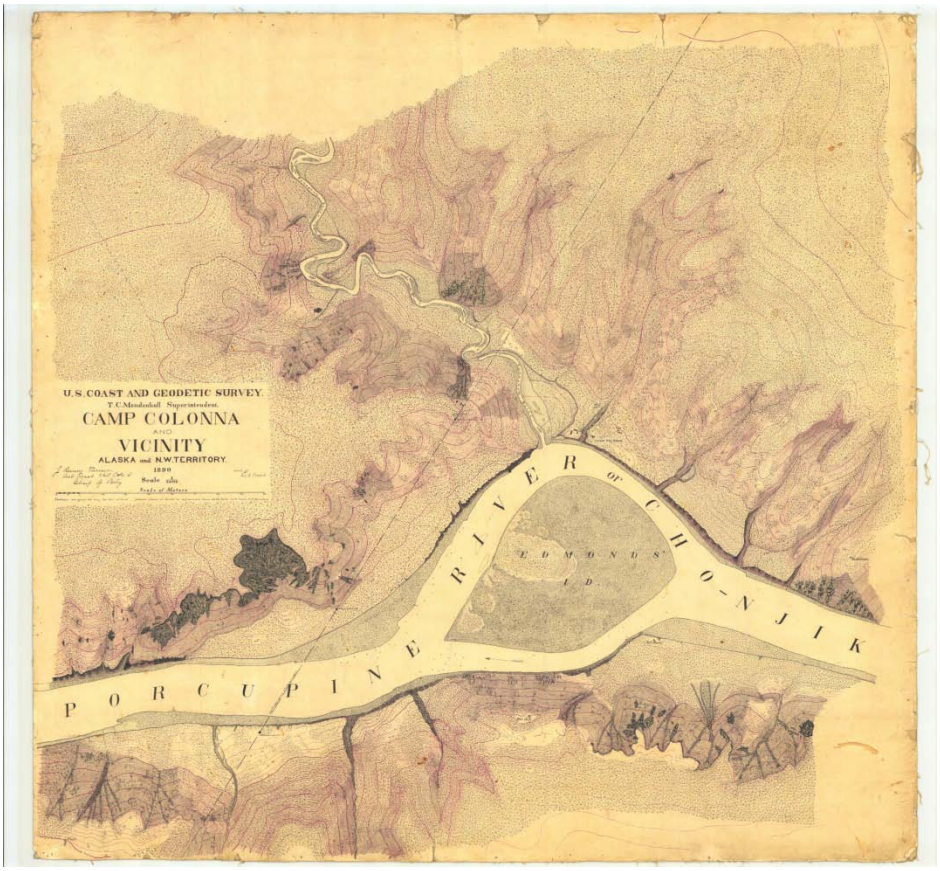
30. Wrecks; where usually occurring; do wrecked vessels usually go to pieces in first storm? There are places where to remain on board is safest, on others the only hope is in reaching shore, as vessel goes to pieces. Give this outline in full.

The final section is the Schedule of Statistical Subjects. It concludes with a final paragraph, which in many ways can be considered an ethnographic and cartographic apex of the U.S. Coast and Geodetic Survey and the U.S. Government in general, in that era. It states in full:

9. Special attention is called to the nomenclature of all points named, especially Indian names. Where the orthography is doubtful, care should be taken to obtain the best authority for the name and spelling used, that confusion and correction upon our printed charts may be avoided and the charts themselves may become the best future historical authority. Where different and doubtful spellings of apparently equal weight are found, all such should be used in the report. All changes in nomenclature, where known, should be noted."

F.M. Thorn
Superintendent

The Survey's attention to the Instructions, and specifically relative to Indian names, is exemplified in the t-sheet prepared as part of the Survey's occupation of an observatory above the Arctic Circle in 1889, as part of a more or less cooperative effort by the United States and Great Britain to more accurately locate the 141st meridian, which is the largest single section of the boundary between Canada and Alaska. It had been roughly determined previously, but the advent of the Canadian and Alaskan gold rushes made it imperative to both nations that the meridian be determined with far more accuracy. The Survey crew that did the work established Camp Colonna, to honor their colleague whose field work days were over. Camp Colonna was located on a bend of the Porcupine River, or, as noted, is Cho-Njik, its name in Gwich'In, an Athabascan language of the Yukon,.



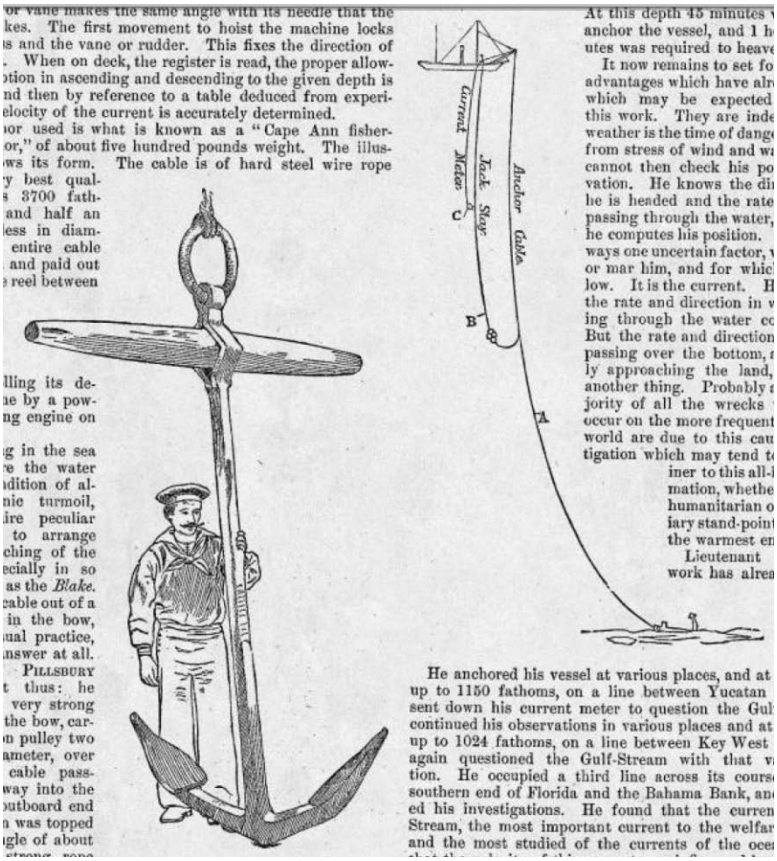
T- 2066 Camp Colonna and Vicinity
On the Porcupine River, or Cho-Njik
Field work and observations in 1888-89, but the map
was not returned and registered until 1890.

Hydrography

"…and in this logical order hydrography comes last" was really phrased in the arena of political logic. Hydrography has already come up repeatedly in discussion of Survey work in the Thorn era. Beyond matters like Henry Mitchell's celebrated analysis of the tidal regimes of New York harbor, aided by William Ferrel's harmonic analysis of the tides at Governor's Island in the harbor,[31] and allied work, the major arena left untreated thus far is the Survey's continued oceanographic explorations of the Gulf Stream and the Gulf of Mexico. The research included the deployment of increasing

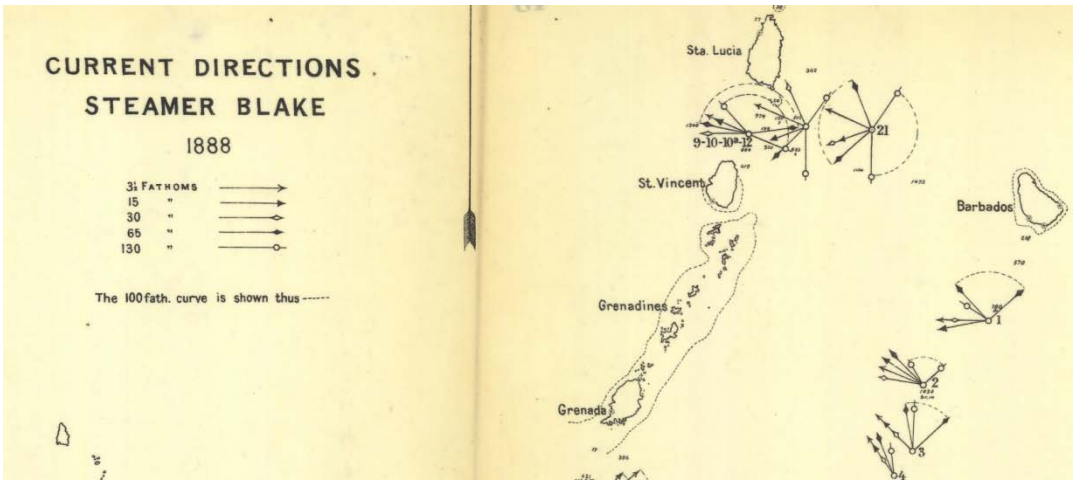
[31] Ferrel, 1885, App. No 13, pp. 489-493.

sophisticated equipment that could record current speed and direction data reliably at great depths.



The Cape Anne's Fisherman's Anchor adapted to use in the Survey's current meter system, shown on the right, in Henry B. Well's Supplement to Harper's Weekly, October 20, 1888

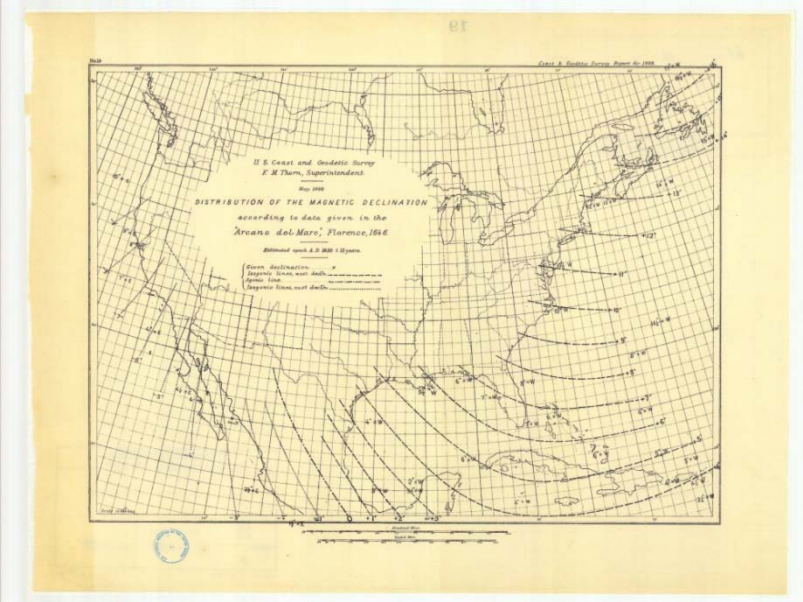
The new system could be used to acquire current data at specific places and at specific depths, so that the flow structure of water in the entire water volume could be more readily apprehended.



Current Directions and depths in the Caribbean (crop)
From Figure No. 43, Annual Report for 1889

Magnetic Observations

This field was listed last in Colonna's description of Survey field work, in the context of producing "the perfect map". That would be literally true, in that the diagram of true and magnetic north with its estimate of anticipated yearly changes in the direction of magnetic north at that point (the annual secular variation) was always calculated and engraved last in the map production process. But by the nature of terrestrial magnetism, observations and their analysis were pursued constantly, in every area the Survey worked in. One relatively new endeavor in the field of the magnetic elements in the Thorn era was the development of major projects to reconstruct the configurations of magnetic declination in and around North American for specific epochs going back centuries into the past. These reconstructed magnetic epochs could then be used to correlate historic azimuthal bearings and correct them to true north.



Historic Magnetic Declination in the Epoch of 1646
Reconstructed from the "Arcano del Mare" in Florence
By Charles A. Schott Sketch No. 19,
Annual Report for 1888

These maps and data of epochs of historic magnetic declination were closely associated with an intense period of analysis of historic maps and charts related to the entire history of western exploration of the New World. Much of this, in turn, had been triggered by popular and scholarly attention to the Survey's re-publication, in 1884, of much of the body of Dr. Johann G. Kohl's reconstructed maps related to the history of the discovery and exploration in the western hemisphere, a project that began under Superintendent Bache in the 1850s.[32] George Davidson conducted his own research on historic magnetic declinations on the northwest Pacific coast, as well as examinations of many of the early voyages there between 1539 and 1603.[33] Finally, Charles A. Schott, the Survey's great computer, wrote both a massive compendium on the geographic variation and secular variation in magnetic dip and intensity (as opposed to magnetic variation) in the United States, and also wrote an analysis of the complex magnetic work of Greely's Expedition above the Arctic Circle. For a finale, he wrote an appendix detailing the entire history of magnetic research in the Survey.[34]

"…the production of a perfect map"

Assistant Colonna's sequence of different types of field work prosecuted in a logical order to end with "a perfect map" was accurate, although the purposes of each specific discipline were much broader than map production alone. Nevertheless, it must

[32] Kohl, 1855, 1856, 1857, and 1884.
[33] Davidson, 1885, 1886.
[34] Schott, 1885, 1887, 1888.

be noted that the Thorn tenure, however tenuous and doubtful it might have seemed at the beginning, by the end had become another golden age of cartographic production in the history of the Survey. This reflected Thorn and Colonna's efficient management, and possibly as well the knowledge by all who remained with the Survey that they had to do substantially better or the Survey's prospects were very dim.

The amount and quality of the maps produced under Thorn led to a series of systemic improvements, culminating with the creation in 1887of a Chart Division, formed out of operations that had been lumped with many other activities and products in the Miscellaneous Division. As the Annual Report explained:

"In December, 1887, the Chart Division was organized, and Assistant W.H. Dennis was instructed to take charge of it, his special duty being to have the custody of the charts and to direct their correction and issue. He reports that the total number of charts disposed of during the year was forty-four thousand five hundred and ninety-five, which was an increase of nearly 30 per cent, over the issue of the year before. Of this number, twenty-five thousand two hundred and seventy-three were sent to agents for sale; eleven thousand six hundred and eight issued to meet demands from the Executive Departments, and two thousand four hundred and eighty-three in response to requests from members of Congress.

"Mr. Dennis calls attention to the fact that during the last six months of the year upwards of three thousand one hundred corrected charts were sent to the Hydrographic Office of the Navy, where, notwithstanding the very critical examination to which they were subjected, not a single error was found for which the Chart Division was responsible."[35]

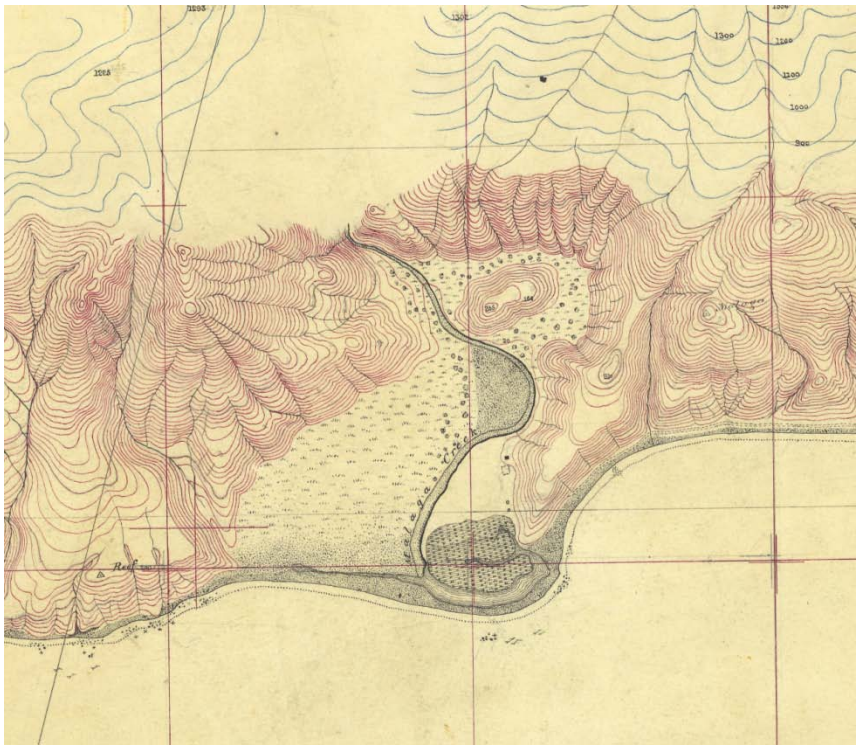
The recurrent theme of the Thorn tenure as Superintendent was how the Survey could not only make do with less funding, but also do more with less. One example of the latter is exhibited in Thorn's letter of January 20, 1888 to the House Committee on Appropriations, subtitled "An estimate from the Superintendent of the Coast and Geodetic Survey to supply deficiency for expenses of the Bureau for the current fiscal year". The letter opens a revealing window into the heart of the Survey's cartography of the era. Thorn contrasts the cartographic regime under the later Superintendent Patterson to the new realities imposed on the Survey as a result of the many Congressional and Executive investigations of the Survey and the fall of Hilgard. He notes:

" For the purpose of promoting excellence and uniformity in the quality of the field sheets [i.e., the topographic sheets, or t-sheets] the late Superintendent Patterson several years ago established the practice of having the professional draughtsmen in this office ink the sheets which had been originally drawn with pencil by the field officers.

"The inevitable effect of this practice was to divert a number of the draughtsmen from the business of reducing the drawings of the field sheets to the scale of the charts, thereby relaxing the production of the charts. The resulting improvement in the sheets

[35] Thorn, Report of the Superintendent, 1888, pp. 90-91.

was not only open to dispute, but it afforded no compensation for the delay in publication of charts consequent upon such diversion of the labor of the draughtsmen"[36]



A section of T-1432A Johnson Station to Point Dume, California (1877)
from the Patterson era showing the draughtsmen's inking
over partially erased pencil lines

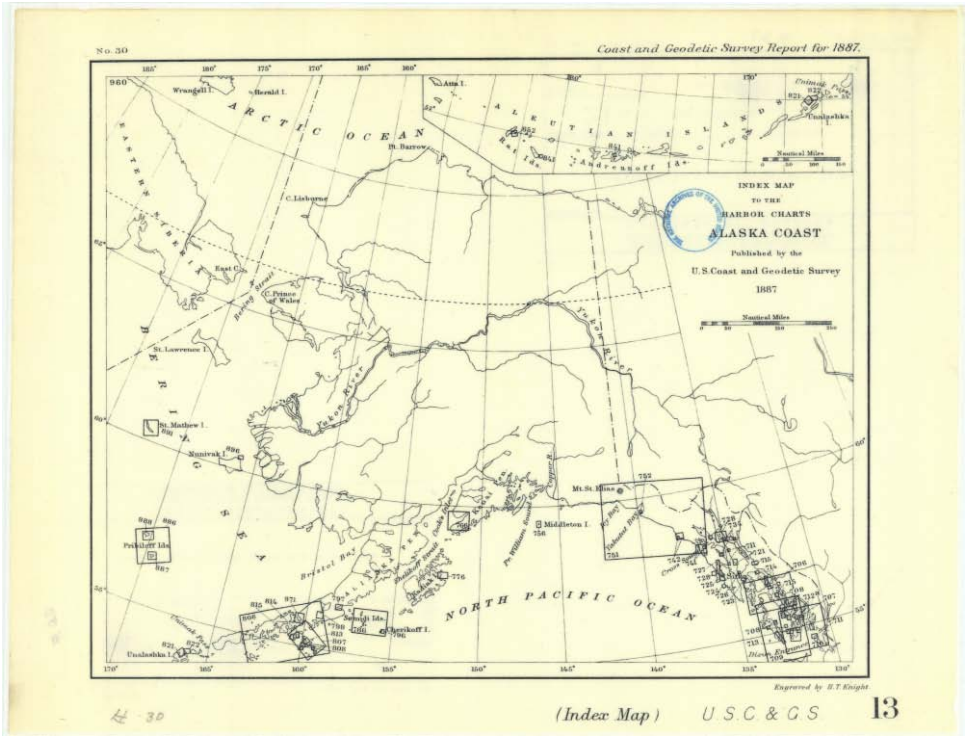
Thorn goes on:

"Accordingly, several months ago we suspended the practice referred to, directing the field officers to ink their own sheets, and were thereby enabled to render available directly, in drawings for charts, the services of several draughtsmen whose time had theretofore been occupied in the inking of topographic sheets. The consequence is, that since the 1st of July last, a period of substantially six months, we have been able to place in the hands of the photolithographer drawings of twenty-one new charts—double the usual number for such a period—besides thirteen index maps and three new editions of charts, all of which are substantially published at this date. … This large number of photolithographic charts and ten additional charts now engraved on copperplate, and awaiting only the engraving of the titles and notes, we are reasonably sure of being able to issue by the 1st of July next, if the appropriation for which I now estimate can be obtained… Without such additional appropriation the issue of the twenty-eight charts mentioned is liable to a delay of a year or more. Such delay in the production of charts in the past has not only been the occasion of annoyance to the management of the Survey

[36] Thorn, 1888, in 50th Congress, 1st Session, Executive Document No. 111, p.2.

and of criticism by others, but it always largely impairs the value of the chart and of the survey and all the work which it represents. "[37]

Thorn's appeal for extra funding was successful, and the new charts were soon published, including the first set of chart index maps ever produced and included in the annual report.



Index Map to the Harbor Charts Alaska Coast
Figure No. 30, Annual Report for 1887

The chart publishing process that Thorn directed had evolved considerably from the days of Hassler. During his tenure, Henry Wells, a writer and editor of Harper's Weekly, produced an extensive report on the functioning of the many branches of the Survey. His description of the inter-relations between the finished topographic and hydrographic sheets, the Survey's photographic transfer process, plate engraving and the use of the charts derived from the original plates is as comprehensive a description as exists for the era.

"Great judgment and skill are requisite that no useful detail be omitted on the one hand, while on the other the drawing is not made obscure by needless repetition. This done, the original sheet, bearing the signature and approval of every officer who has had a hand in its production, is filed away in the archives of the bureau. Not a single mark is

[37] Ibid, p. 2.

permitted on any chart of the Coast Survey the authority and responsibility for which cannot be fixed at a moment's notice.

"The new drawing is then traced on another paper with a peculiar ink. A plate of copper is then provided, except in point of size and thickness, exactly like a visiting card plate. The polished surface of the copper is covered with a solution of wax in turpentine, the tracing is inverted upon it and rubbed, and upon removal of the tracing every line is found printed on the copper plate just as it is to be engraved. The engraving is like that on a visiting-card plate, all lines being below the surface.

"The engraving completed, a proof is taken. This proof is examined by every officer who has had to do with the production of the drawing. Every mistake in his department must be indicated, and he must certify upon its margin in writing that there are no others. On the chart of Delaware Bay are 18,000 figures of soundings. Every one of these is verified individually. The plate is then corrected and a new proof struck off. The same routine of verification is had, and if no further errors are found, an edition of seventy-five copies, and no more, are struck off for immediate use. All subsequent copies are printed from an electro-plate duplicate of the original plate.

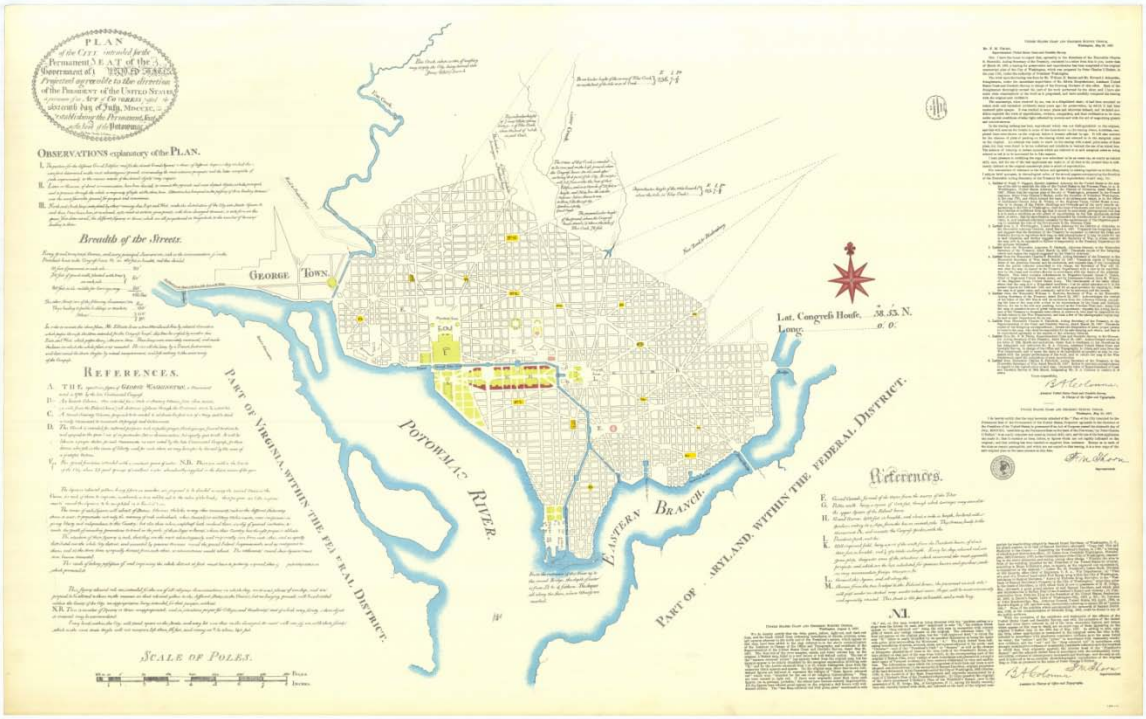
"The mechanical and artistic work on these charts is simply superb—we have already spoken of the intellectual work they embody. The writer has compared them with English, French, German, Dutch, Spanish, and Italian charts, and they are almost as superior in execution to the best as the mechanical execution of a greenback was superior to that of a Confederate note."[38]

The profusion of new maps, and maps of newer subjects, and especially maps outside the usual array of nautical charts and harbor charts, etc., was eventually formalized in 1886 by the creation of the 3000 map series, which was a block of chart numbers starting with 3000, which was the 1886 republication, for whatever reason, of an 1853 harbor chart of Plymouth, Massachusetts, as opposed to a contemporary revised edition of chart 338, the Plymouth harbor chart. In addition to republishing historic nautical and harbor charts, the 3000 series was used to re-publish a sub-set of the Survey's maps created during the Civil War, and many one-of-a-kind maps, such as the republished 1874 topographic map of Hoosac Mountain by Charles S. Peirce, which was an integral part of his gravity station work at and inside the mountain.

In keeping with the systematic work on historic magnetic declination epochs and the revived cartography of discovery and exploration by Johann Kohl and George Davidson, Assistant Colonna discovered a very rare copy of Pierre de l'Enfant's original schema for the development of the Capital of Washington, rolled up behind a desk in the Survey's headquarters, or at least that was the story It must be said that this was a providential moment for the map to show up, as the Survey was in the midst of topographic surveying, at the behest of Congress, the area of the District of Columbia formerly called the County of Washington, outside the City of Washington. The distinction between City and County had been erased in the early 1880s, so the Survey's

[38] Henry Wells, 1888, p. 806

task was to prepare detailed topographic maps of the major area of the District, which now was to be developed in some accordance with the ever evolving Plan of L'Enfant.



Plan of the City intended for the Permanent Seat of the Government of
The United States, etc. 1790 by Peter Charles L'Enfant
Chart 3035A, 1887

The extensive commentary by Thorn and Colonna, printed on the map, in addition to descriptions in the annual report, indicate that the map original was considered historically significant and critically detailed, but it had aged so badly that no literal reproduction of it would serve. So the artists of the Survey re-constructed the map in a mock-archaic cartographic style faithful to the original, but using different and much more vibrant colors than L'Enfant has used originally. At the same time, the extensive commentary described every change they had made. At the same time, the Survey re-published in a similar way Dermott's 1798 map of the City of Washington as Chart 3034B, and W.J. Stone's 1839 Washington City map, now Chart 3036.

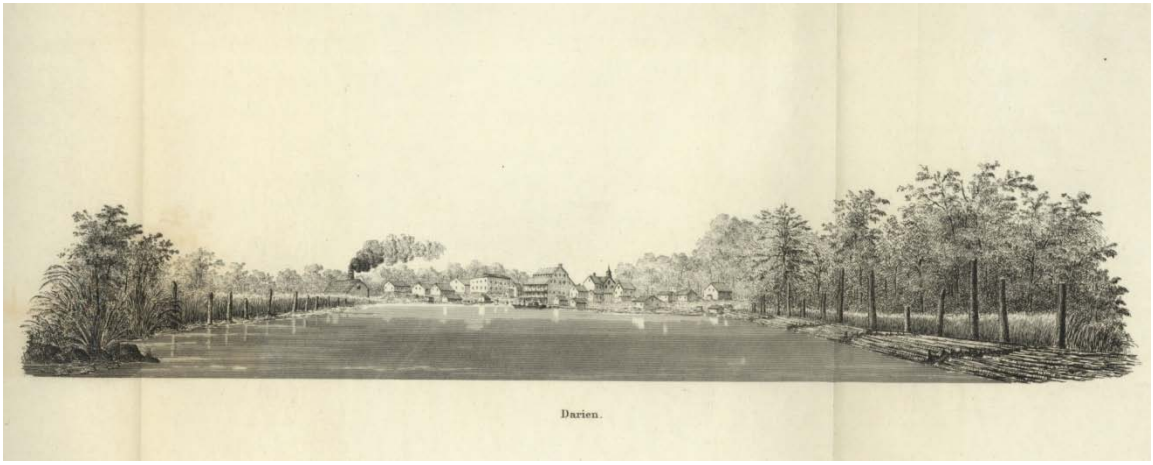
In keeping with the new series of index maps to the regular series of Survey nautical charts, the Survey also prepared an extensive and comprehensive index to all figures and sketches ever published in the Annual Reports, from 1844 through 1885.[39]

The Coast Pilots, Atlantic and Pacific

[39] Goodfellow, App. No. 12, 1887.

The Survey had long produced coastal guides and sailing directions, beginning with George Davidson's 1858 Directory of the Pacific Coast. After the Survey acquired the Blunt's Coast Pilot series in 1867, they were called Coast Pilots, in various editions. Significant revisions and new material on both sides of the continent culminated in Thorns' tenure in two landmark publication series in the history of the Survey.

On the Atlantic coast, previous editions of the Atlantic Coast Pilots were revised and completed, to create in 1887 and 1888 the unified series of Atlantic Local Coast Pilots, in 22 sub-divisions, from the Bay of Fundy to the Florida keys. The revised series featured, in all but sub-division 22, the extraordinary coastal views of John Barker, who began work for the Survey in the Peirce tenure, and worked until his death in Patterson's tenure.

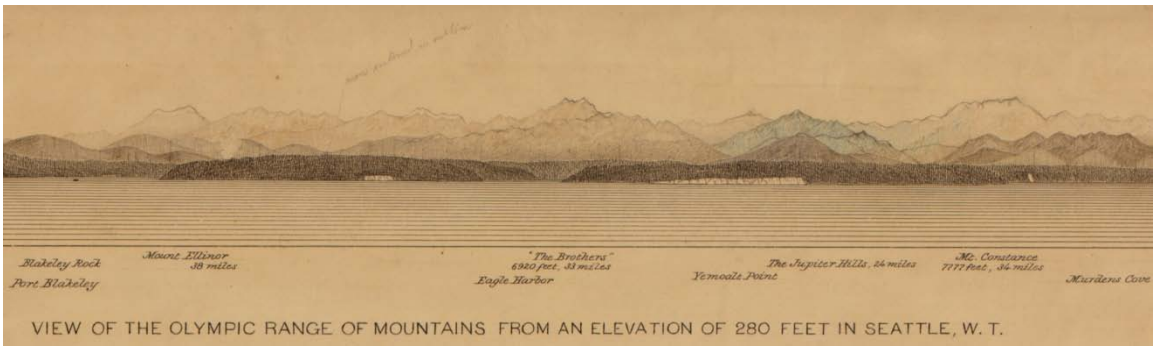


Darien, Georgia by John Barker, 1887
Atlantic Local Coast Pilot Sub-Division 21
Tybee Roads to Jupiter Inlet

Barker's work began in the North Atlantic as visual aids to navigation, but as he worked his way south, his drawings and his own engravings derived from them became primary records of American maritime history and technology as Barker had found them. These were both the culmination, and the finale, of Survey coastal views on the Atlantic coast.

The Pacific equivalents to the Atlantic Coast Pilots had begun under George Davidson in 1858. Especially after the work expanded to include Alaska, more specialists were recruited to the work, including William Dall and Marcus Baker. In 1880, at the request of Superintendent Patterson, Davidson started work on what would become the 4th revised edition of the Pacific Coast Pilot. In 1883, he inducted the superbly talented draughtsman and hydrographer Ferdinand Westdahl to the task of preparing coastal views, in addition to views by Davidson himself. Westdahl worked from San Diego to Vancouver Island during 1884-86 on the views. Davidson also brought in Cleveland Rockwell, and Assistant Gilbert to draw views. Rockwell then transferred and revised the views for engraving. These were combined with Davidson's text, which had been

completed in 1886 but then revised and edited. These culminated, in 1889, with the Pacific Coast Pilot, George Davidson's *magnum opus*.



View of the Olympic Range (and "the Fauntleroys") from Seattle
Original view by Ferdinand Westdahl 1884-86

1889 marked the completion of the Pacific Coast Pilot, and the end of Thorn's tenure as Superintendent. During his tenure, the Survey assisted other government agencies and institutions in graphic projects as well as scientific research. One such collaboration involved the Smithsonian Institution. They were attempting to renew or republish an engraving by the celebrated American painter Asher Durand. In 1835, Durand had completed a celebrated painting, his copy of John Vanderly's "Ariadne Asleep on the Island of Naxos". He then made and published a copper engraving based on his painting. It was this engraving that the Smithsonian wanted to revive. Survey specialists were recruited to guide making a new copper plate derived from a photographic transfer from an original print, a process previously described by Henry Wells in the *Harper's Weekly* Supplement. The engraving displays the classic Mediterranean Sea in the background. Therefore, the engraving might be considered a final sly gift of the Superintendent, who had been a professional humorist for most of his life. "Ariadne Asleep on the Island of Naxos" was, in a sense, the Survey's last published coastal view.

"Ariadne Asleep on the Island of Naxos" by Asher B. Durand, 1835
As republished by the Smithsonian Institution, 1889.

The End of (the First) Cleveland Administration and Superintendent Thorn

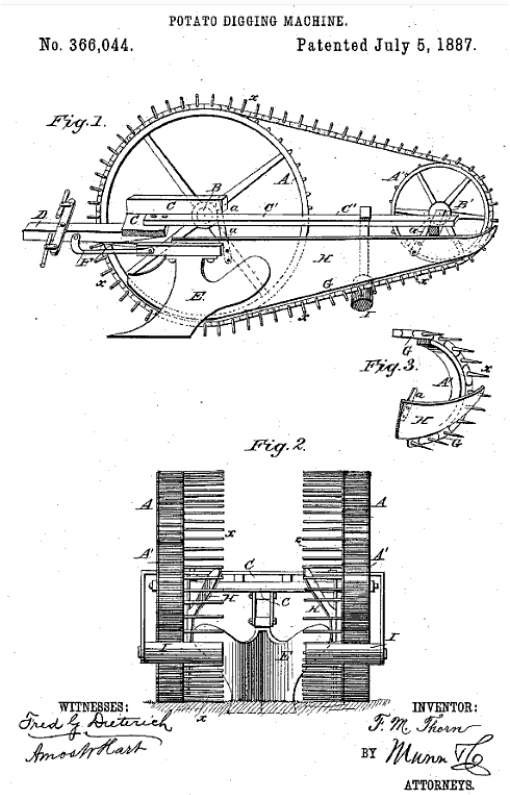
The same tide whose flood had brought in Frank Manly Thorn as Superintendent washed him out on its ebb. It was clear to all, particularly to him, that his tenure would be limited, regardless of the results of the 1888 election which President Cleveland lost. The Survey had been so compromised by scandal under Hilgard that it was impossible for his successor to rise from within the Survey itself. The next Superintendent had to come from without. Thorn was selected by Cleveland because he was an intelligent, competent public servant and, of course, in the retinue of Cleveland—but he was not a scientist. Much of the Survey's prestige, if not its competence, had always come from its status as the premiere scientific agency in the government, and that requires scientific leadership, however competent Thorn was. And he had succeeded quite well. As the *New York Times* headline put it: "Not So Bad for Layman. Three Years' Management of the Coast Survey. President Cleveland's Appointment of Superintendent Thorn Fully Justified by Results."[40]

Yet it wasn't Cleveland's defeat in 1888 that brought an end to Thorn's tenure. It was, instead, the continuation of the same kinds of actions by Congress which had

[40] New York Times, April 14, 1889, p. 1

brought down Superintendent Hilgard. Throughout the previous history of the Survey, the Superintendent had been appointed by the Secretary of the Treasury. President Cleveland appointed Thorn to his post. That gave the Congress the opportunity to have a role in choosing the Superintendent, under the clause allowing the Senate to "advise and consent" to Presidential appointments. In between Cleveland's defeat in November, 1888, and President Harrison's swearing-in in March, 1889, the Senate added an amendment to the Sundry Civil Bill, requiring the Superintendent of the Coast and Geodetic Survey to be appointed by the President with the consent of the Senate. As soon as the full Congress passed the bill[41], Thorn's days were numbered, as he had not received Senate confirmation or even a hearing, nor had he even participated in the Allison Commission hearings. Thorn stayed on into President Harrison's term as a placeholder and leader of the Survey, pending the appointment—and Congressional investigations of—his successor, Thomas C. Mendenhall. He then returned to the farm and estate in Orchard Park, New York, outside Buffalo, and resumed his former life as a gentleman farmer and public figure.

Frank Thorn eventually held three U.S. Patents on his designs for improved potato diggers.[42] His second patent, shown here, he designed, applied for, and received while serving as the Superintendent of the U.S. Coast and Geodetic Survey. One can say Thorn himself resumed a life in Orchard Park that was "new and improved".


POTATO DIGGING MACHINE.

No. 366,044. Patented July 5, 1887.

Fig. 1.

Fig. 3.

Fig. 2.

WITNESSES: Fred G. Dieterich, Amos W. Hart

INVENTOR: F. M. Thorn

BY Munn & Co.

ATTORNEYS.

[41] Congressional Record, 50th Congress, 2nd Session, February 19, 1889, p. 2044.

[42] Patent No. 327,357, granted September 29, 1885; Patent No. 366,044, granted July 5, 1887, and Patent No. 437, 528, granted September 30, 1890.

Potato Digging Machine Patent No. 366,044
F.M. Thorn, Inventor

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